The Welding Engineer

Edited by L. B. Mackenzie

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Purchase your Oxygen under specifications — both for quality and quantity.

Air Reduction Sales Company prefers to sell you on this basis.

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ANYTHING and EVERYTHING for OXYACETYLENE WELDING and CUTTING

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In use or needing repair?

Repair Stations

IF YOU are a user of Oxweld apparatus, you may be sure that your equipment is working efficiently, because Oxweld fieldmen do inspect it from time to time, make adjustments, and supervise minor repairs.

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Detroit	Michigan
Chicago	Illinois
St. Louis	Missouri
Minneapolis	Minnesota
Omaha	Nebraska
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Seattle	Washington
San Francisco	California
Los Angeles	California

ASK your master mechanic or welding foreman to check your oxy-acetylene welding and cutting apparatus. How much of it is in service and how much needs repair?

You know that all the machinery and apparatus in your plant requires constant adjustment and sometimes repair. This is the result of use, and occasionally, of abuse. Your oxy-acetylene equipment is no exception.

If your welding and cutting equipment is Oxweld, repairs and adjustments are not a source of worry. You know that Oxweld fieldmen inspect it from time to time, make adjustments, and supervise minor repairs. You know also that near you is one of the Oxweld factory repair stations, which makes major repairs. It is not necessary to ship your apparatus to our factory, because the repair stations listed at the left can do equally good work in much less time.

In buying oxy-acetylene equipment, consider the nearness of repair service. Later, this will be important to you. Oxweld apparatus, including these repair facilities and other services, requires only a moderate investment.

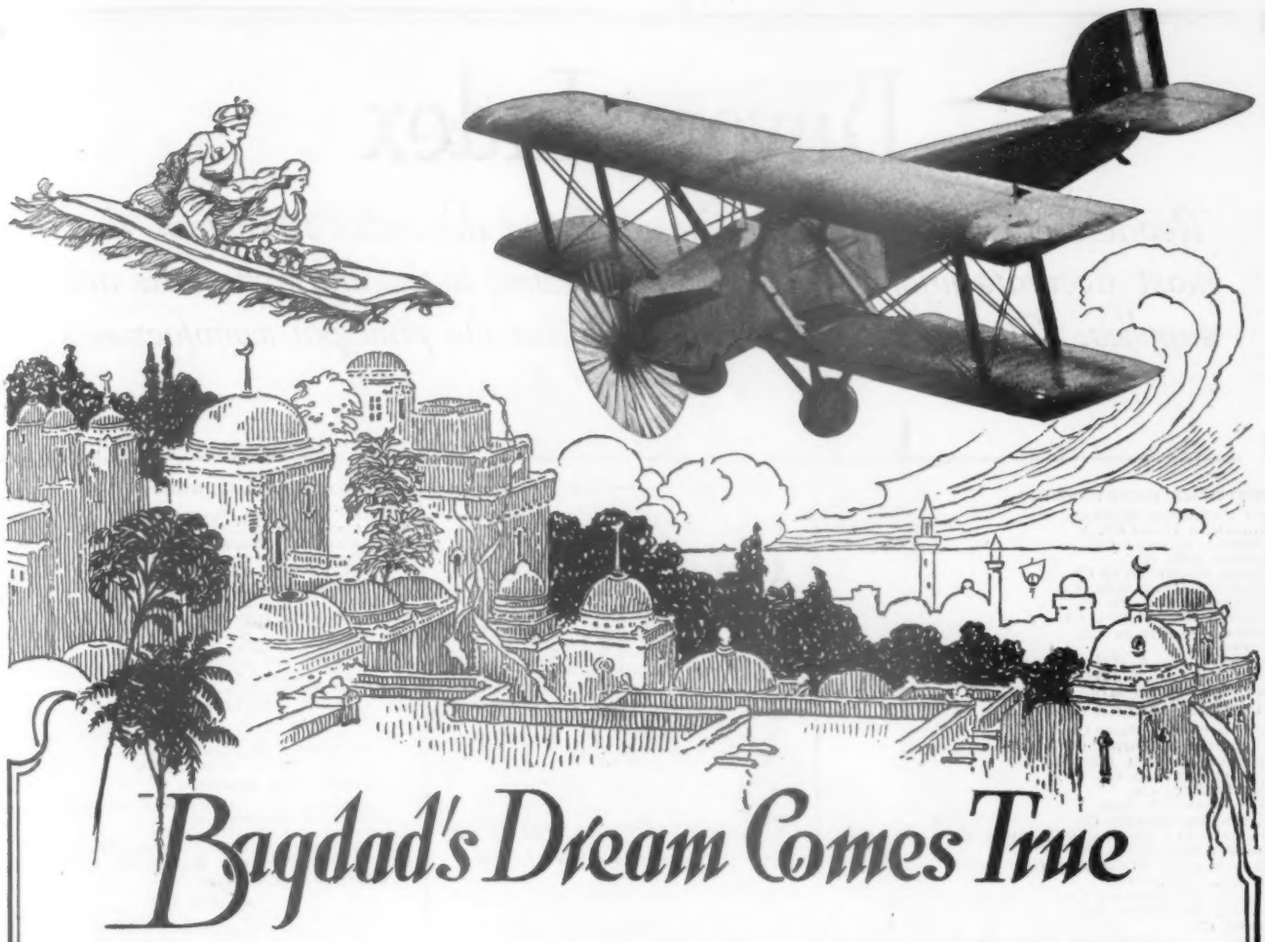
OXWELD ACETYLENE COMPANY

Chicago	Long Island City, N.Y.	San Francisco
3642 Jasper Place	Thompson Ave. & Orton St.	1050 Mission Street

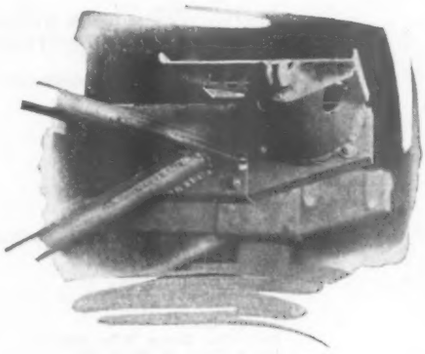
Oxweld

WELDING AND CUTTING APPARATUS

WORLD'S LARGEST MANUFACTURERS OF WELDING AND CUTTING EQUIPMENT



Bagdad's Dream Comes True



FACTS are sometimes stranger than fiction and the Magic Rug fairy story of the Arabian Nights is tame compared to the true story of the United States Army's Round-the-World flight.

The brave men, who made this epoch-making trip, could not have succeeded without confidence—complete confidence in themselves and in their splendid Douglas planes.

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Buyers' Index

Readers of The Welding Engineer will find this index to contain the most accurate information obtainable relating to welding apparatus and supplies. The advertising section includes the principal manufacturers of the United States.

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Air Reduction Sales Co.
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Purox Co.
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See "Torches"

BOOKS (Relating to Welding)
The Welding Engineer
Electric Arc Cutting & Welding Co.

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We not only do welding, but supervise the design and installation of oxy-acetylene welding plants; report on welding material and methods; make tests on welding apparatus for efficiency and economy.

Nine years' experience.

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CARBON (Blocks, Paste, Etc.)
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National Carbon Co.
U. S. Welding Co.
Electric Arc Cutting & Welding Co.

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See "Torches"

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Chicago Steel & Wire Co.
Wm. Cramp & Sons
Davis-Bournonville Co.
Electric Arc Welding & Cutting Co.
International Oxygen Co.
Modern Engineering Co.
Mutual Auto Spec., Inc.
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Oxweld Acetylene Co.
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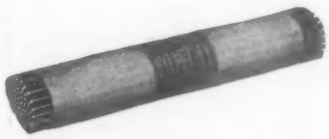

Welding Wire

for Steel, Cast Iron, Brass, Bronze, Monel Metal and Aluminum

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Wm. Cramp & Sons
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Modern Engineering Co.
The Imperial Brass Mfg. Co.
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Purox Co.
Page Steel & Wire Co.
Superior Oxy-Acetylene Machine Co.
Transportation Engineering Corp.

FILLER RODS (Tobin Bronze)
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Alexander Milburn Co.
American Brass Co.
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Burdett Oxygen Co.
Central Steel & Wire Co.
Bierman-Everett Fdy. Co.
Carbic Mfg. Co.
Davis-Bournonville Co.
International Oxygen Co.
The Imperial Brass Mfg. Co.
Modern Engineering Co.
Oxweld Acetylene Co.
Purox Co.
Page Steel & Wire Co.
Superior Oxy-Acetylene Machine Co.
Torchweld Equipment Co.
United States Welding Co.

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Reid-Avery Co.
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Bierman-Everett Foundry Co.
Carbic Mfg. Co.
Davis-Bournonville Co.
Imperial Brass Mfg. Co.
Modern Engineering Co.
Mutual Auto Spec., Inc.
Purox Co.
Welding Metals Mfg. Co.

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Burdett Oxygen Co.
Carbic Mfg. Co.
Davis-Bournonville Co.
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International Oxygen Co.
Imperial Brass Mfg. Co.
Purox Co.
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Purox Co.
Quasi-Arc Weldtrode Co.
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Torchweld Equipment Co.
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Carbic Mfg. Co.
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Harris Calorific Co.
Imperial Brass Mfg. Co.
International Oxygen Co.
K-G Welding & Cutting Co.
Alexander Milburn Co.
Oxweld Acetylene Co.
Purox Co.
Superior Oxy-Acetylene Machine Co.
Torchweld Equipment Co.

HYDROGEN
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Gas Products Association
International Oxygen Co.

HYDROGEN PLANTS
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International Oxygen Co.

KEROSENE PREHEATING TORCHES
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Bastian-Blessing Co.
Carbic Mfg. Co.
Davis-Bournonville Co.
The Imperial Brass Mfg. Co.
Imperial Brass Mfg. Co.
Modern Engineering Co.
Oxweld Acetylene Co.
Purox Co.
Superior Oxy-Acetylene Machine Co.
Welding Metals Mfg. Co.

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Burdett Oxygen Co.
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Davis-Bournonville Co.
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The Imperial Brass Mfg. Co.
K-G Welding & Cutting Co.
Alexander Milburn Co.
Purox Co.
Superior Oxy-Acetylene Machine Co.
Torchweld Equipment Co.
Welding Metals Mfg. Co.

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Modern Engineering Co.
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Carbic Mfg. Co.
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Harris Calorific Co.
International Oxygen Co.
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Purox Co.
Oxweld Acetylene Co.
Superior Oxy-Acetylene Machine Co.
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Harris Calorific Co.
International Oxygen Co.
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K-G Welding & Cutting Co.
Alexander Milburn Co.
Modern Engineering Co.
Oxweld Acetylene Co.
Purox Co.
Superior Oxy-Acetylene Machine Co.
Torchweld Equipment Co.
United States Welding Co.
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Modern Engineering Co.
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Purox Co.
Superior Oxy-Acetylene Machine Co.
Torchweld Equipment Co.

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Harris Calorific Co.
Imperial Brass Mfg. Co.
Alexander Milburn Co.
Oxweld Acetylene Co.
Purox Co.

SAND BLAST
Transportation Engineering Corp.

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International Oxygen Co.
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San Francisco....351 California St.

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CONNECTICUT
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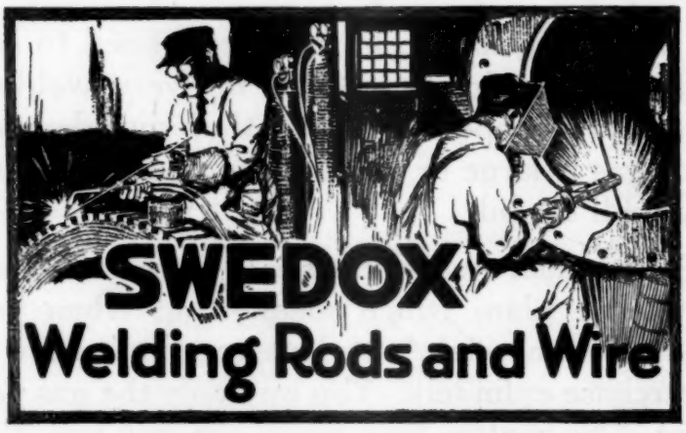

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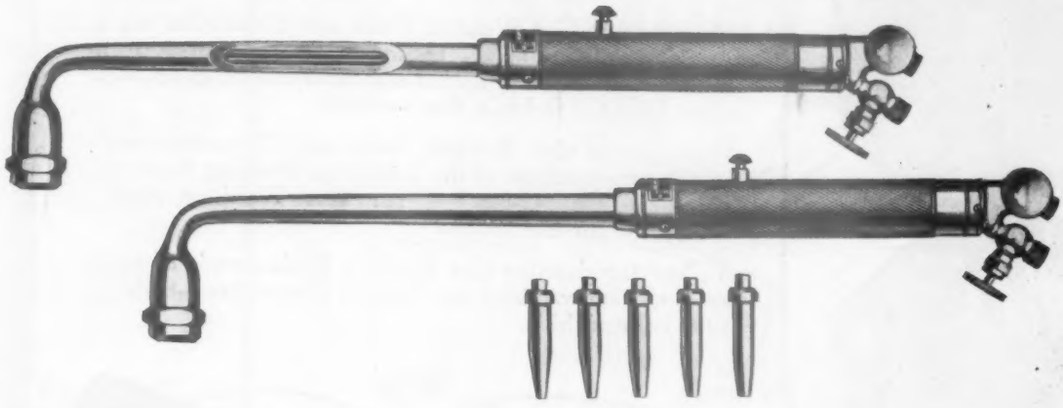

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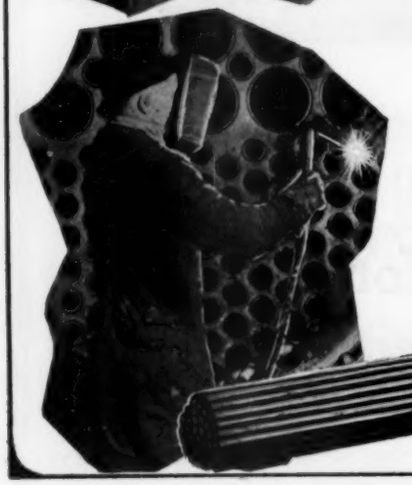

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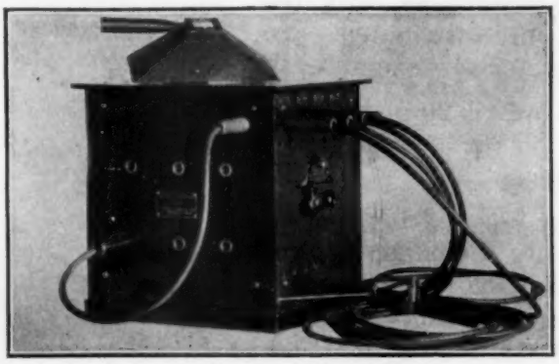

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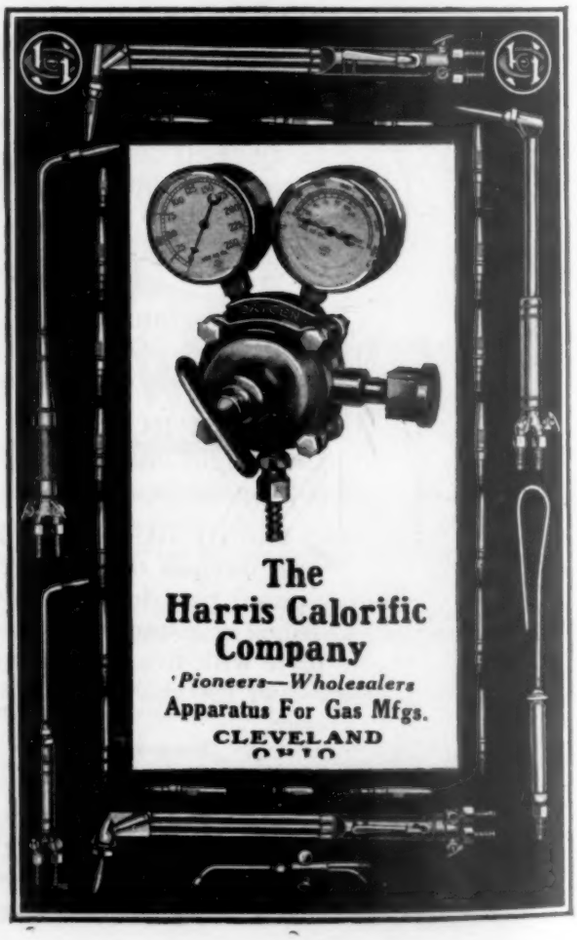

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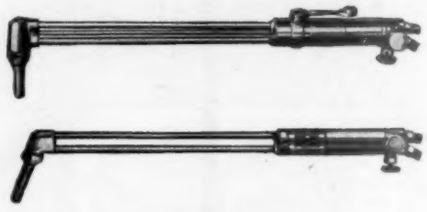

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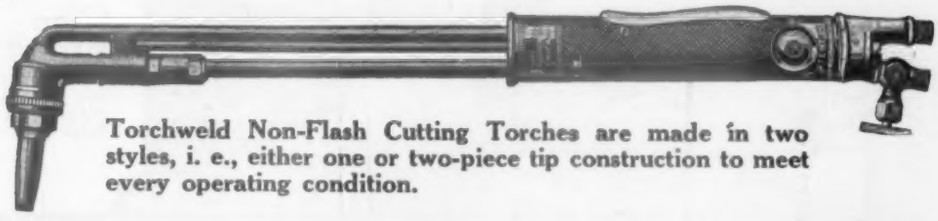

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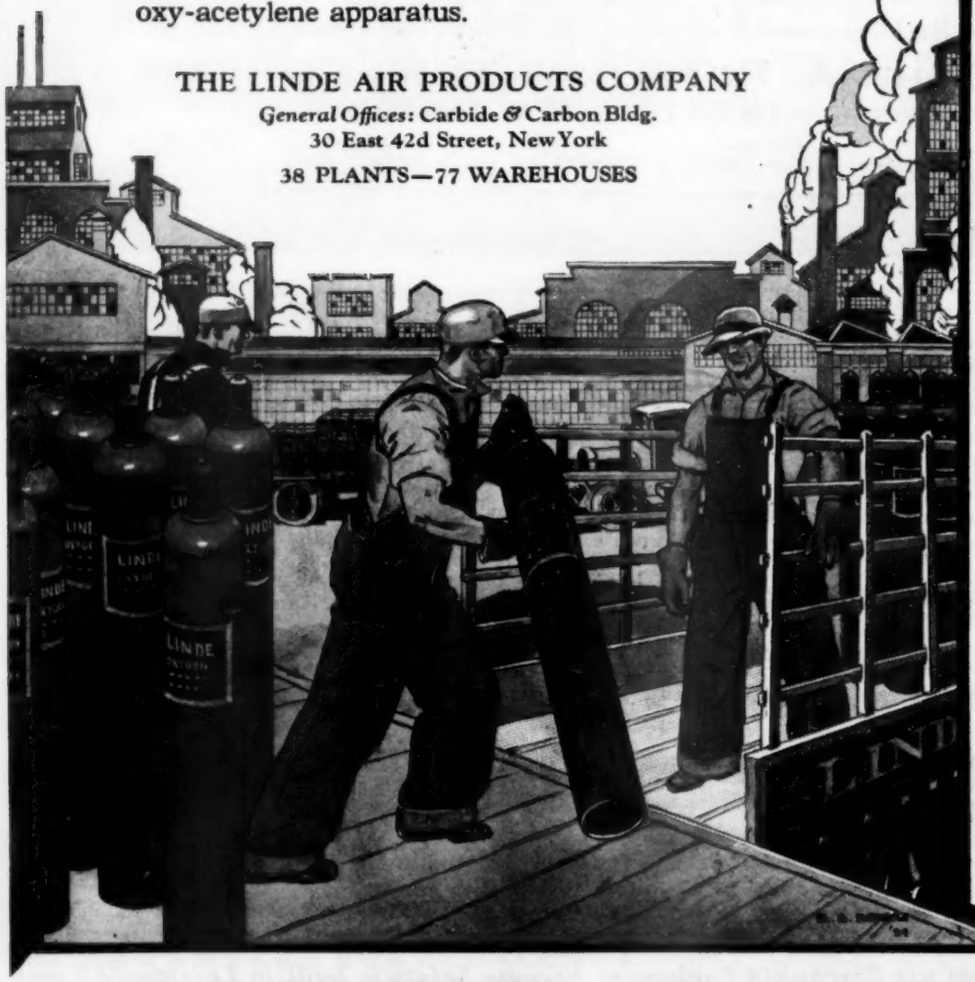

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WELDING IN PLUMBING AND HEATING

Work Done in Place with Oxy-Acetylene Cutting and Welding—Joints, Connections and Special Fittings Economically Welded

By H. E. Wetzell*

THAT excellent results are attendant upon the use of the oxy-acetylene process for installing piping in buildings has been demonstrated. It is a new field for welding but the several jobs handled in this manner are giving entirely satisfactory service. Oxy-acetylene welding recommends itself to owners, engineers and architects in this field because welded piping assures durability and simplified system. For the same reasons it recommends itself to the plumbing and heating contractors who should be especially interested because welded piping costs less and is easier to fabricate and install. Most of the work can be done on the job. Old lengths, miscut pipe, difficult bends and special fittings for example, present no obstacles to the contractor

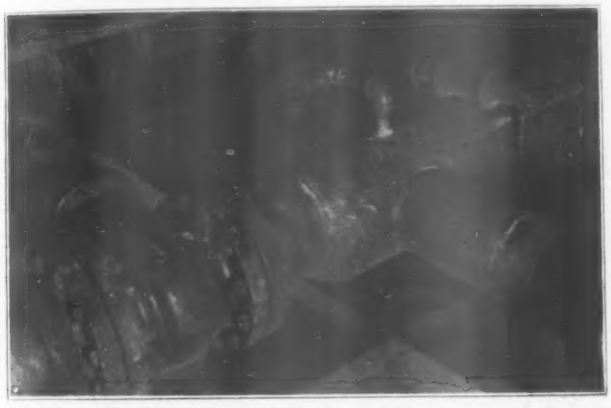

Fig. 1

equipped with welding and cutting facilities. Problems that formerly meant long and expensive delays are now executed on the job with consequent savings for the contractor, builder and owner. In fact, all trades installing pipe in buildings are rapidly coming to recognize the all around desirability of adopting the oxy-acetylene process in their work.

In relation to many other fields of endeavor that of installing pipe in buildings is unique because piping layouts are seldom twice the same. Consequently, individual problems confront the contractor on each new job. But here is where the oxy-acetylene process is particularly advantageous. After a man has learned to use his cutting and welding blowpipes on pipe he can do almost any piping job regardless of the size, shape, position or extent just as a good carpenter with his hammer and saw can put up almost any wood structure.

Joints, connections and special fittings on high and low pressure steam, compressed air, vacuum, cold water and brine lines are economically welded. The accompanying illustrations are photographs taken on one job which the writer has lately had opportunity to observe. They were snapped at random points about the building while it was under construction.

In determining wherein oxy-acetylene cutting and welding can be employed advantageously these factors are usually considered.

1. Strength of a welded joint in comparison with other types of joints.
2. Tightness
3. Durability
4. Weight of piping
5. Comparative costs involving
   - a.—original installation
   - b—time
   - c—handling
   - d—upkeep
   - e—covering
6. Appearance
7. Possibility of easy alteration
8. Possibility of certain special construction.

In most cases it will be found that in each item the oxy-acetylene method has the weightiest arguments in its favor.

The actual strength of any individual welded joint can only be definitely determined of course, by actual test. But if good welding practices are adhered to and each weld carefully made the joints can be made even stronger than the pipe itself. This has been proved repeatedly by both field and laboratory tests. And as to the strength of a welded joint in comparison with a screwed joint, welding involves the addition of metal whereas threading involves removal. Common sense dictates the answer.

The same is true in relation to tightness. Those features which permit leaks to develop and make them possible with all other types of joints do not exist in welded construction. Once a welded joint is properly executed the possibility of leaks is reduced to a minmum. Its permanent tightness is undoubtedly one of the outstanding advantages of welded piping in buildings, as the expense, inconvenience and damage caused by leaky piping in this field is on the whole greater than in other piping fields.

Modern building construction involves such a large quantity of piping that weight also has become an important factor. It is involved mostly of course in connection with fittings, and any cast fitting weighs greatly in excess of one fabricated by welding. The latter contains less metal and such parts of cast fittings as flanges and bells are eliminated.

Fig. 2

Cost is a variable factor. Typical joints might easily entail slightly different expenditure on the same job. Yet as the results on a large number of jobs have shown, under average conditions it is easy for a contractor to determine the average or maximum costs for different types of connections and fittings and these can be used for figuring on prospective work. Observations under all sorts of working conditions have established the cost of screwed connections and the larger the pipe size the greater is the saving over them by welding. Other factors of cost, such as the time required to complete a welded connection, the amount of handling involved, upkeep, and the cost of applying covering, are less, when welded joints or fittings are compared with other types.

*The Smith and Oby Co., Cleveland, Ohio.

Take the four welded connections—Fig. 1 or even the single "T" Fig. 2. Each of these was fabricated on the job. The chance of error was eliminated and accurate fittings obtained at a very small fraction of the cost of cast fittings which would have been required to obtain the same results.

Appearance may not always be considered of great importance, but wherever it is there can be little question but what a pipe line with a surface unbroken by unsightly fittings or bulges is the more pleasing in appearance. Especially is this true where the piping runs through a finished section of a building.

The several welded joints and connections shown in Fig. 2 are typical examples of piping fabrication which is accomplished on the job, often after the main line or fitting is in place. This is a high pressure steam line and a practical steamfitter can

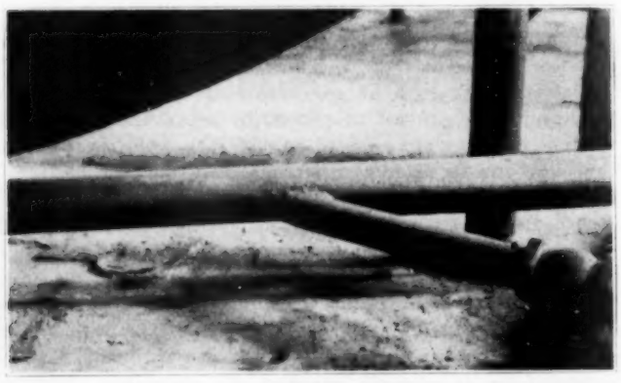

Fig. 3

readily conceive how difficult it would be to obtain such a layout with standard fittings. The same results could of course be obtained with a special casting but such would probably have cost more than re-arranging the whole layout. Besides, to install fittings would have required more time and expense than it did to do the welding shown.

The scope of the cutting and welding process from the viewpoint of the average piping contractor is one of its most valuable assets. If an operator can reach the point on a line to do the necessary cutting and have room to execute a weld, there is hardly an emergency that can arise and not be successfully handled.

A number of instances on one installation illustrate this. For example: After putting in the main steam supply header on top of the battery of boilers, the end of one of the special bends leading from it did not center at the fitting. Instead of sending the bend back to the shop to be changed, the fitting was cut off, another opening was cut in the header, and the bend welded to it. The opening left where the fitting was cut off was closed by welding. This quick work kept the building heated so work could continue on the inside during a cold spell. After installing one line it was desirable to connect six more laterals to it. Instead of taking the line down as would have been necessary were fittings used, the additional laterals were run up to the main line like that shown in Fig. 3. Then an opening was cut in the line and the joint welded.

In Fig. 1 both "T" connections were installed after the large pipe was in place. The "T" connection in Fig. 2 was made under the same circumstances. Every job as large as this one involves numerous occasions where such changes in the original piping layout are necessary. If the contractor has to make them by the old methods—"extras" pile up. But where the changes are made the oxy-acetylene way, everyone involved saves. Anticipation of what these savings amount to will often enable a contractor to submit a lower bid.

In any building, additions and changes in the various piping systems may be necessary in the future. The extent to which welded construction is employed is in no way a detriment when such changes or additions are desirable. They can be accomplished with the cutting and welding blowpipes to better advantage, at less cost, and in the majority of cases, without dismantling the piping in place. What an improvement this is in comparison with taking down a whole section of piping.

As other metal trades have acknowledged the advantage of the oxy-acetylene process and have accepted it in place of the older methods, so now the plumbing and heating contractors are adopting it for their work.

BUILDING UP LOCOMOTIVE TIRE FLANGES

By H. D. Adell*

Having heard many arguments against and few *for* the practice of building up locomotive tire flanges, I thought my experience might be interesting and may be of some benefit to someone.

In the past year we have built up more than a hundred flanges without one cause for regret. Of this number we had one drive tire break before the weld was completed, and had a flange crack on a trailer tire before the weld was complete. In the first instance investigation developed the fact that the tire had been expanded the limit in resetting, and after the welder had left the job at quitting time, a thoughtless helper threw a bucket of cold water on the tire at the hottest point, causing a sudden contraction and also sudden breakage. The second instance was a trailer tire which was extremely thin and had the flange renewed twice before. From all indications in breaking in this tire, it had become crystallized or fatigued from long service.

During the year we have been rebuilding flanges and have had no trouble of any kind that could be attributed to built up flanges, and the problem of returning tires only happens in the event of high flanges, and even then in case of emergency it is possible to cut them down with a cutting torch and make a passable job of it.

Due to the great number of short curves on this line and their fast wear on flanges, the success we have had is most gratifying and especially money saving. We are using the electric process only for this work, and it is no uncommon occurance for a welder to complete two 48 inch drives in 6 to 7 hours, making a good smooth job with the proper contour.

We use a circular motion with the electrode making bulk of fill on upward stroke and smoothing up on the downward stroke, using high carbon sod on reversed polarity. It takes some practice to get the proper movement of electrode on this stroke to making smooth application, but after becoming accustomed to it or getting the knack it is the easiest I have ever tried.

For the welding of locomotive frames we are using ordinary boiler steel electrode and have yet to experience our first failure in a weld or in any other sort of frame where it could be attributed to the welded point. Where possible we use the double "V" method of cutting the frame making it as narrow as possible and yet enabling the operator to work freely in the bottom of the "V." Allowing ⅛ inch to ¼ inch for contraction, due to the size of the frame, we apply about two layers of metal on each side in the bottom of the "V." and from there on out use an air gun or bobbing tool after each layer, hammering it thoroughly (this also removes all scale) and finishing with a flush weld.

A great many welders argue a heavy reinforcement, but I believe a *competent* operator with the right electrode and thorough fusion is wasting time in making a heavy reinforcement, though this is a question for the mechanical engineer to figure out according to rigidity in one part of the frame affecting other portions. I really believe that figures will go against reinforcing in preference to flexibility. We have had some very severe tests for welded frames and the flush weld having made good we are sticking to it.

**Welding Foreman, Missouri and North Arkansas Railway Co.*

METAL ARC WELDED SHIPS

Residual Stress and Other Fundamentals in the Design of Metal Arc Welded Ships and Welded Structures in General

By James W. Owens*

THE writer has followed with interest the series of articles in *Marine Engineering and Shipping Age* by Mr. E. H. Ewetrz, covering available information on the application of arc welding to ship construction. The collection of this information, and its preparation in a form suitable for publication, represents considerable labor on the part of Mr. Ewertz; nevertheless, there is, except in Lloyd's rules on joint design given in his last article in the February issue, a lack of fundamental information which a designer must have if he is successfully to apply metal arc welding to the repair and construction of ships.

The article in which Lloyd's rules are given concludes with the following quotation from a paper by Mr. F. B. Webster:

"Another custom and prejudice to be overcome is the overlapped and strapped joint. We have seen from the tests described above that the butt joint is the strongest, both for tensile strength and alternating stresses, but in spite of this, Lloyd's require the lap joint. The lap joint is not only weaker, but it is a positive menace."

As Lloyd's rules and the views expressed by Mr. Webster are diametrically opposite, it is evident that both cannot be correct, consequently a ship designer, considering the use of metal arc welding, will be literally at sea. Under the circumstances, one can hardly blame shipbuilders for sticking to riveting until there is a more general knowledge of the fundamental principles of welding, consequently, I have very largely confined my article to a statement of fundamentals, as I have been enabled to arrive at them through extensive research for the Bureau of Construction and Repair of the U. S. Navy for several years, and a critical analysis of practical welding conditions and service tests of welded structures, which it has also been my privilege to supervise and observe in this research program. I will preface this article by stating that I am in agreement with Lloyd's on the question of joint design, *i.e.*, their requirement that lap joints be used and not butt joints, and that, should a butt joint be used, it must be strapped.

Selection of Joints

In selecting a welded joint to be used in a ship's structure, or indeed any type of structure, the following should be considered, relative importance being in the order given:

(a) Value of residual stress in the joint or structure.
(b) Mechanical properties of the joint.
(c) Ease of assembly.
(d) Facility of welding.
(e) Speed and cost.

Value of Residual Stress in the Joint

Residual stress may be defined as "the stress or stresses remaining in a welded joint or structure on completion of welding":†

This stress is ad-fected, that is, raised or lowered, by many factors, the principal ones being:

Form of welding used,
Carbon content of the base metal,
Type of joint.

The laws of residual stress are as absolute as the law of gravity and the designer of welded structures, the failure of a weld of which might involve a loss of life, should give the subject serious thought.

Form of Welding

Metal arc welding is the only form of welding considered in this article, as the writer considers *gas welding* unsuitable for the welding of the hull of a ship, due to the general necessity of using the semi-rigid type of joint, which requires a free movement of at least one plate during welding; *thermit welding* is only applicable to the welding of heavy sections, such as a broken stern frame; and *resistance welding* has not as yet reached a stage of development which warrants consideration.

Carbon Content of the Base Metal

The higher the carbon content of the base metal, the higher the residual stress, consequently ingot iron has the lowest residual stress and should therefore preferably be used for butt joints

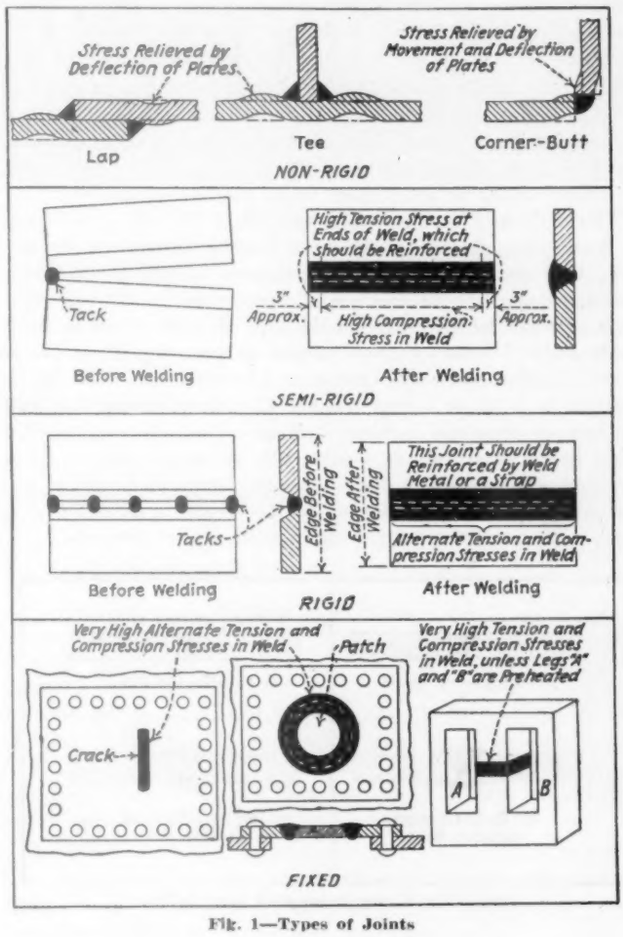

Fig. 1—Types of Joints

as specified later. Ship steel as at present used for the riveted structure has a carbon content of approximately 0.25 per cent, therefore, if a decided extension of welding is to be seriously considered by shipbuilders, this steel must be used, as it is available and readily obtained under present specifications; furthermore, it is essential that the joints which are incorporated in a 0.25 percent carbon steel structure be those in which the residual stress is low, so that there is no possibility of failure from this cause.

As welding gains a foothold in shipbuilding, there certainly will come refinements which will call for a change in the present

*Electrical engineer, Norfolk Navy Yard. In charge of welding research for the Bureau of Construction and Repair, U. S. Navy.

†"Fundamentals of Welding," by James W. Owens.

specifications for ship steel thus permitting the use, to a greater or less extent, of butt joints.

The specifications for steel to be welded prepared by the American Welding Society and the American Society of Mechanical Engineers require a carbon content not in excess of 0.15 precent, but it must be borne in mind that the material ordered under these specifications is used principally for the fabrication of un-fired pressure vessels, the designers of which frequently specify butt joints.

Types of Joint

Joints have been classified by the writer into four principal types, viz., the non-rigid, semi-rigid, rigid and fixed (see Fig. 1).

Fig. 2—Open Butt Strap Joint

This classification is based largely on practical considerations, involving a number of factors, the most important of which is the value and distribution of *residual tension stress in the weld metal* of the joint.

The residual tension stress in the weld metal of the non-rigid type is the lowest, that in the semi-rigid and rigid types come next, although distribution is different in each, while the tension stress in the weld metal of the fixed type is the highest of all.

Examples of the non-rigid type of joint are the lap, tee, corner butt and the open butt strap, this matter being merely a butt strap joint in which the edges of the butt are straight, separated by a distance of at least twice the thickness of the metal, and all edges welded by independent fillets (see Figs. 1 and 2).

The resistance to the contraction forces of the weld metal in these joints is low, producing a bending moment in the section, thus securing direct tension stresses which are uniformly distributed throughout the joint. *No cracked welds have ever been observed by the writer in this type of joint, either in welds made under laboratory conditions or in sea-going structures in locations where they were subjected to maximum stress.* Welds referred to involved a large number of test specimens, thousands of feet of structural welding, and were made in standard ship plate up to 40 pounds in weight. No particular weld or layer sequence was adhered to, the number of layers used varied from one to four, and electrodes up to 7/16 inch in diameter were used, with current values as high as 375 to 400 amperes.

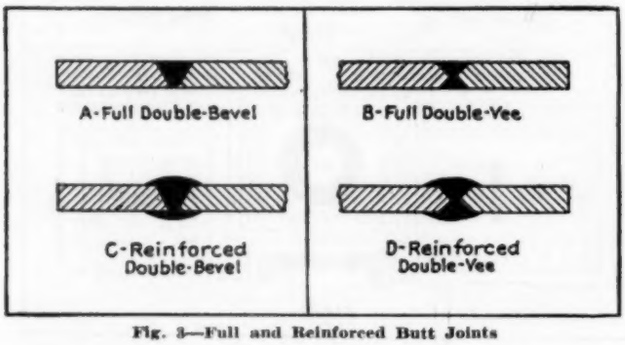

Fig. 3—Full and Reinforced Butt Joints

The semi-rigid type of joint (Figs. 1 and 3), is a double-bevel butt joint, having its surfaces in the same plane, joint edges allowed to close gradually as welding proceeds, and weld made in one unbroken layer. The weld metal of the completed joint is in tension for about 3 inches at each end of the weld, the remainining weld metal being in compression.

Apart from the high tension stress in the ends of the joint, this type of joint is unsuitable for ship construction due to the necessity of having at least one plate free to move as welding proceeds. A blow is not necessary to cause failure, and when it does occur, will always take place at the ends of the joint. This stress distribution and location of failures has been proved by the writer in numerous tests, and observations of structural welds.

The rigid type of joint (Figs. 1 and 3), can be either of double-bevel or double-vee butt form. Its surfaces are, like the semi-rigid type, in the same plane. Joint edges are parallel, tacked prior to welding, and at least one of the plates must be free to move as welding proceeds. If this latter condition is not fulfilled, the joint automatically becomes a fixed type, with even greater residual stresses. The weld metal of the rigid type of joint is alternately in tension and compression throughout the whole length of the joint, and failure is likely to take place in any section of the joint, a blow not being necessary. A blow on a compression area is likely to cause failure in an adjacent tension area. This distribution of stress and location of failures has, like the semi-rigid type, been proved to the writer's satisfaction.

Examples of the fixed type of joint (Figs. 1 and 3), are a prepared crack in the central portion of a plate of comparatively large area, and a butt welded patch in the port hole of a ship. Joints may be of double-bevel or double-vee butt form.

In such joints, there is either no possibility of movement of joint edges, as in the previous type, to partially relieve the forces of contraction set up by the cooling weld metal, or all possibility of movement is eliminated by the weld metal itself soon after the weld is commenced, consequently contraction of the weld metal can take place only by elongation of the fibers of the base and weld metals. Distribution of stress and its magnitude, also location, cause and extensiveness of failures are similar to that of the rigid type of joint. As noted under the rigid type, the stresses in the fixed type are of a much higher magniture. Failure is more likely to start at the finishing point of the weld. These conditions have also been proved to the writer's satisfaction.

Dangerous Types of Joint in Ship Structures

The tension stress in the weld metal of the semi-rigid, rigid and fixed types of joint are of such magnitude in standard ship plate of 0.25 per cent carbon content, as to require these joints to be classed as dangerous when used in weights of material as employed in the strength members of a ship. A crack once started, in these types of joint, is likely to extend throughout the whole length of the joint and might even continue into the component parts of the structure, due to the phenomena of "crack continuity," as will be shown in the service tests of welded bilge keels referred to later. These stresses are of lower magnitude in material of lighter weights, *e.g.*, 7½ pounds, due to the short transverse contraction length of the weld metal, less heat required to produce fusion, relative ease of warping, etc. When these types of joint are used in a ship's structure, they should always be reinforced by a strap as required by Lloyd's, with the additional requirement, that the butt be welded before the second fillet of the strap.

The writer considers that reinforcement of a butt joint in 0.25 per cent carbon steel by weld metal, will not take care of the additional stresses to which a ship structure is subjected under sea-going conditions.

Mechanical Properties of the Joint

Lap, Tee, Corner-Butt and Open Butt Strap Joints. Using standard ship plate and bare low carbon steel electrodes, the writer has found that a 40 per cent efficiency can be expected with a full continuous fillet weld on one edge of the *lap*, 90 to 100 per cent efficiency with a full continuous weld on both edges of the lap. If fillet welds are reinforced so that the throat of the weld is 10 to 15 per cent greater than the plate thickness, an efficiency of 65 per cent can be obtained with one fillet weld, and fracture will consistently occur in the plate with both fillet welds thus reinforced.

When two fillet welds are used, bending, whether due to a static load or impact, will always take place in the plate, and not in the weld, due to the stiffness of the joint. This joint is, there-

fore, ideal for ship structures, as working stresses are entirely in the base metal and, in case of collision, there is small chance of the weld failing. The second fillet introduces a factor of safety, for should poor fusion, by any chance, exist in a section of one fillet weld, the second fillet would likely insure an efficiency high enough to be within the factor of safety allowed in the design.

Should joggled laps be used, the weld should not be made in the joggle, a distance of at least ⅛ inch being left between the bottom of the joggle and the toe of the fillet weld. If design requires the joggle to be filled with weld metal, this weld should be made before the one on the other edge; the writer, however, considers that an element of risk would be introduced in a ship's structure should a joggled lap be so welded in standard ship plate.

The comments on the lap joint are also applicable to *tee and open-butt strap joints.* Consideration should be given to the reinforcement of the *corner-butt joint,* when this joint is introduced into a strength member. Reinforcement can be made by weld metal on the open side of the joint. Additional reinforcement can be secured by weld metal on the inside of the corner; however, to effectively transfer working stresses from the weld metal of the joint to the plate material, consideration should be given to the use of an angle or angle clips, either on the inside or the outside of the corner.

Any efficiency desired by the designer can be secured with lap, tee and open butt strap joints, as weight and continuity of weld metal can be varied within wide limits by using combinations of light, full and reinforced welds, with broken and unbroken weld sequences. In corner-butt welds, 100 per cent efficiency can be obtained by reinforcement as specified.

Butt Joints. The writer does not recall ever having tested either a double-bevel or a double-vee butt joint made with bare low carbon steel electrodes, using 15 or 20 pound standard ship plate, which has shown an efficiency of 100 per cent in tension when the weld metal has been ground flush (Fig. 3) with the surfaces of the base metal; however, he has consistently had the base metal fail when these joints have been reinforced on both sides (Fig. 3) about 20 per cent of the thickness of the base metal. In double-bevel butt welds, reinforcement on the bottom of the bevel was the same width as that on the open side of the bevel, and extended on to the base metal on both sides of the bevel. He considers that the average efficiency of un-reinforced double-bevel or double-vee butt welds in standard ship plate should not be estimated higher than 40 per cent. It must not be overlooked, however, that the possibility of failure from residual stress is always present.

Other investigators have, I believe, secured 100 per cent efficiency in test specimens of un-reinforced butt welds in ship plate using alloy electrodes, nevertheless the magnitude and distribution of residual stresses in a butt weld of a test specimen and those in a structural butt weld are not necessarily the same due to the fact that the fixities of the two welds might be widely apart on account of the comparatively small size of the specimen and the large area of the plates welded in the structure, and other factors introduced by the very nature of the job; consequently the danger of failure of the structural weld from this stress is ever present.

Ease of Assembly

Lap, Tee, Corner-Butt, and Open Butt Strap Joints. Lap, and open-butt strap joints are ideal for assembly. Plates can be ordered neat as it does not make any difference whether the lap is plus or minus an amount within reason, and surfaces can be in intimate contact. In general, ⅞ inch assembly holes are punched in the center of the lap, 2 to 3 feet apart for ¾ inch bolts. Holes are subsequently welded, or plugged and welded. The weight of the structure can be reduced by making the width of the lap ½ or ¾ inch, but as this would not permit the use of an assembly bolt through the faying surfaces, holes can be punched in one plate adjacent to the lap and a strap used to pull the surfaces together. Such a joint is stiffer than a butt joint and has all the inherent advantages of the lap joint without the disadvantages of the butt.

If both fillets are welded in a non-watertight structure, such as a battle towing target, and a narrow lap used, the cost of welding the holes is avoided, if it is desired to keep water out of the faying surfaces so as to eliminate corrosion.

Tee and corner-butt joints are readily assembled by angle clips, holes in plates being punched on centers used for the lap joint. The edge of the plate forming the tee should not be beveled, and can be assembled in close contact with the other plate. If a backing strip is used in the welding of a 90 degree corner butt with high current values, it is not necessary to have these edges ⅛ to $\frac{3}{16}$ inch apart, as is generally customary in butt welds. With corner butt welds having an acute angle, this opening is essential to secure fusion in the bottom of the weld.

Fig. 4—Metal Arc Welded Battle Towing Target Built at the Norfolk Navy Yard

Butt Joints

Except in very light metal, it is necessary that the edges of the rigid and fixed types of butt joints be assembled so that they are ⅛ to $\frac{3}{16}$ inch apart in order to secure fusion in the bottom of the bevel, or center of vee, and to prevent plate edges overlapping during welding.

Due to the foregoing, considerable difficulty is encountered in securing proper alinement. It is also necessary to tack the joint edges prior to welding, tacks being spaced approximately 6 inches apart. The cost of fabrication and assembly is much greater in this form of joint due to the labor required in beveling the joint edges, difficulty of assembly and cost of tacking.

Facility of Welding

Lap, Tee, Corner-Butt and Open Butt Strap Joints. Beveling of plate edges is not necessary in these joints; uniform heat conduction is secured in the weld, and electrodes as large as $\frac{7}{16}$ inch diameter can be used with current values as high as 375 or 400 amperes. These high current values *insure* deep penetration, uniform fusion eliminates inspection of every foot of the weld and overcomes the criticism of those who maintain that a weld cannot be inspected and a riveted joint can be.

The writer has seen inspected reveted joints in a ship structure in which the rivets were not driven home, thus casting doubt on the supposed unfailing reliability of tapping rivets, with a machinist's hammer to determine soundness.

Full welds in these joints can be made by one layer, and there is no necessity of an unbroken layer sequence to keep the temperature of the joint within practical welding conditions. A step-back section sequence is sometimes used for one layer welds in order to employ very high current values and yet keep the joint temperature low; however, a step-back section sequence is usually not necessary for the second layer, or the second fillet of lap and tee joints.

Butt Joints. Unless a semi-rigid type of joint is used, it is usually necessary to make welds, in 15 and 20-pound plate, in two layers. Electrodes above $\frac{7}{16}$ inch diameter are not in general advisable, and great care has to be exercised by the welder

to prevent the liquidification of too much metal in the bottom of the bevel, which usually requires low current values for the first layer, with the possibility of poor fusion; or the use of a backing strip. Non-uniform fusion in the bottom of double bevel, and slag in the center of double-vee butt welds are likely to occur.

Speed and Cost

In the comparative construction of riveted and welded battle towing targets at the Norfolk Navy Yard, lap, tee and open butt strap joints in 15-pound ship plate were welded in the flat position with ⅜ and 7/16 inch electrodes, and one continuous layer. A maximum rate of deposit was obtained in excess of 5 pounds of metal per man hour, with an average rate of 3.5; and a maximum speed in excess of 12 feet per man hour, with an average

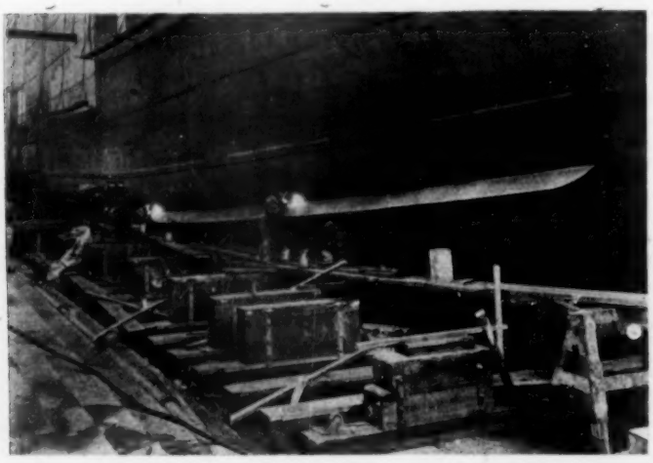

Fig. 5—Bilge Keel Being Welded on a Ship at the Norfolk Navy Yard

of 7.75. With this rate of deposit, the actual cost of labor and material to drive the rivets was practically the same as that of welding. With the further development of automatic and semi-automatic machines, suitable for ¼ and ⅜ inch electrodes, the actual cost of depositing the metal will be much lower than the actual cost of driving the rivets. The direct labor costs on every other item involved in fabrication, preparation and assembly are lower for the welded targets, except the cost of moving material, which is slightly greater because welded targets are turned over to facilitate welding. The total saving in direct labor on fabrication, preparation and assembly was approximately 21 per cent in favor of the welded target. The saving in weight of material was about 10 per cent.

If the targets were watertight structures, the total savings in direct labor would have been greater, for the riveted joint would have to be carefully calked.

It is not believed that savings in direct labor would be as high, if butt joints were used in the welded targets. The savings in weight of material would have been greater but the structure would not be as strong, as it would lose the stiffening effect of the lap joint.

Practical Proofs

The following practical proofs are submitted to show the unreliability of the semi-rigid, rigid and fixed types of joint in standard ship plate and the reliability of the non-rigid type of joint in the same class of material:

(a) Fifty students taking the metal arc welding course at the Norfolk Navy Yard were required to make several test welds on the completion of their course. The plates welded were 18 inches long and 9 inches wide, and the joint was a double-bevel butt along an 18-inch edge. About 20 per cent of the welds of the semi-rigid type of joint failed either at one end or both ends, without the application of a blow, and approximately the same percentage of one and two layer welds of the rigid type of joint failed between the ends, also without a blow.

(b) Four 18-inch diameter patches were welded in the heavy deck plate of the U. S. S. *Langley* at Norfolk. Double bevel butt welds were used and the morning after the welds were completed, one patch was found on the bottom of the bunker. On applying a sledge to the three others, two of these were immediately dislodged, the welds having completely failed. The fourth patch appeared to be satisfactory.

(c) Numerous double-bevel butt joints of battle towing target *No.* 60,* which was constructed in 1919 at Norfolk, cracked during welding or subsequent to welding, many failing with a loud report, some of the cracks in 18-foot welds being 6 feet long. These joints were of both the rigid and fixed types. This target subsequently broke in two and had to be abandoned. Three more welded targets have recently been constructed at Norfolk (Fig. 4) and another one is now being built, in all of which, lap, tee and open butt-strap joints were used. No welds of these targets failed during construction, although the structure was rigidly assembled prior to welding and welds were simultaneously made in the most convenient location and no particular weld sequence adhered to.

(d) Bilge keels were welded on three ships at Norfolk (Fig. 5) and similar bilge keels on another ship at the Puget Sound Navy Yard. There were two keels forward and two on the after section of the ship. Each keel was of 20 pound ship plate,

Fig. 6—Crack in Shell Plating of a Ship Caused by Failure of a Butt Joint in a Welded Bilge Keel

about 20 inches wide and was assembled in 3 or 4 sections, the sections being joined by a full continuous double-bevel butt weld (Fig. 3). They were attached to the shell plating of the ship with a straight tee joint (Fig. 1), with a full continuous fillet weld on each side. Some of the butt welds were made after the individual sections were welded to the shell. During the three years in which these keels have been in service, failure occurred in several butt welds of one of the ships welded at Norfolk and several of the butt welds of the ship welded at the Puget Sound Navy Yard. In both of these ships, two of their cracked butt welds extended into the shell plating of the ship (Fig. 6). In

**For a description of this job see "The Welding Engineer," December, 1920.*

(*Continued on page* 24)

CUTTING CAST IRON

Chemical Discussion of Cutting Cast Iron by Oxy-Acetylene—The Elements Found in Cast Iron and Their Affinity for Oxygen

By J. Fitzgibbons

HERETOFORE the cutting of cast iron has been a very slow and costly process even when the carbon electrode is used, which has been considered by some as more rapid as well as more economical than cutting the same by the oxy-acetylene process, but by present methods we have built up the speed of cast iron cutting to about half of that of steel.

First, we must consider cast iron, its elements and their affinity for oxygen, for cutting is rapid oxidation and any

Fig. 1—Position of the Rod

element that does not enter into chemical reaction will act as a barrier to our cutting operations.

For example, we will take a cast iron locomotive cylinder; we will find this composition is made up of iron, carbon, silicon, sulphur, phosphorus and manganese containing not greater than 8/10 of each of manganese and phosphorus, 12/100 of 1% sulphur, 1-25/100% to 1-8/10% silicon, carbon in the combined state up to 5% to which we must add the carbon in free state or in graphitic form and the remaining part will be iron.

The manganese possesses a marked affinity for oxygen however and will burn out very rapidly under the influence of the torch, while phosphorous, a non-metallic element, is converted into phosphorus trioxide (P2 O3) and phosphorus pentoxide (P2 O5). These combine with water vapor to form phosphoric acid.

Silicon occurs in two allotropic forms, a brown or yellow amorphous powder and a hard black or grey crystal. The amorphous form is readily oxidized to silica (S1 O2). It is the crystalline form, however, which generally occurs in metals and it is extremely difficult to oxidize this form of silicon with air or oxygen.

Silica is an extremely stable substance which can not be decomposed by the action of heat. It is unattacked by all acids except hydrophloric acid but is acted upon by alkalies with the formation of cilicates. There is one reaction of the element silicon which is of the utmost importance and is as follows: S1 plus CO2 equals S1 O2 plus C. Silicon and carbon dioxide yield silica and carbon. The (CO2) carbon dioxide is formed from the combustion of acetylene, the complete reaction in oxy-acetylene flame is represented by the following equation:

2CH2H2 plus 5O2 equals 4CO2 plus 2H2O, showing also where we get our water vapor to unite with phosphorus.

Graphite crystallizes in a monoclinic system in plates that simulate hexagonal forms, it is black or greyish black having a metallic luster. The specific gravity varies from 1-8/10 to 2½. It burns with great difficulty even in oxygen.

The various forms of carbon are practically not at all attacked by chemical reagents at room temperatures but when heated by the air or in the presence of oxygen, it burns and when sufficient oxygen is present it produces CO2 carbon dioxide.

It has been shown that three parts of carbon by weight unite with 8 parts of oxygen by weight to form carbon dioxide. Carbon does not unite with hydrogen except at very high temperatures.

Fig. 2—Cut Made in Piece of Cast Iron 2½ inches Thick, 30 inches long in 20 minutes

In the structure of an ordinary casting, the grains are all pearlite, the black plates are graphite, the white banded and dotted part is well developed phosphide autotectic.

Iron forms three oxides which placed in their order of oxidation are as follows: Ferrous oxide (Fe O), Ferroso-Ferric oxide or magnetic oxide (Fe3 O4), the Ferric oxide (FE2 O3), Ferric oxide which contains thirty per cent of oxygen is encountered in hydrated form in familiar rust. It is also produced when cutting with an oxy-acetylene flame and an excess of oxygen is used. Since the magnetic oxide (Fe3 O4) contains only 27½ per cent oxygen, the formation of Fe2 O3 in cutting unnecessarily increased the cost on account of the extra oxygen which is required.

Magnetic oxide of iron is formed on iron when the tem-

perature is raised to incipient redness and is produced very rapidly on the exposed surface of molten metal. Magnetic oxide melts at a temperature considerably lower than the melting point of iron or steel but 300 to 400 degrees higher than cast iron and it has a solubility of 1-10 per cent in molten iron.

When cast iron or steel is heated, say with a blow-pipe, at a certain temperature, the surface is covered with a layer of oxide and if the heating continues, the layer of oxide melts whilst the material on which it rests remains in solid state.

The oxide is perfectly stable to heat, being neither decomposed into iron or oxidized in the presence of oxygen to Re2 O3. This oxide combined with the silica and graphite form a slag which must be removed and to remove this, we combine it with iron containing very small amount of carbon.

This rod is fed to the cutting jet at the point in the kerf where oxidation with the cast iron has ceased and directly on top of the slag, causing it to unite with the slag carrying the slog with it through the kerf. Thus it can readily be seen that the position of the melt bar is constantly being changed.

This bar can also be used to force larger deposits of slag thru the kerf by physical action.

The position of the rod is shown in figure (1). The torch has a slow oscillatory movement using 10 to 15 lbs. of acytylene and 65 to 75 lbs. oxygen for a cut 2 to 4 in. thick. The cut made in figure (2) was made in cast iron 2½ in. thick, 30 in. long in twenty minutes time, consuming 10 ft. of acetylene, 70 ft. of Oxygen, using one lb. of ¼ in. iron rod, making kerf ½ in. wide.

In another piece of cast cast iron, by increasing the preheating blaze and oxygen pressure, we were able to complete a cut forty-two (42) inches long in cast iron, five (5) inches thick at the rate of three (3) linear inches per minute.

METAL ARC WELDED SHIPS

(*Continued from page* 22)

one instance, the shell plate was cracked as much as 27 inches above the keel and 8 inches below the keel, and in another instance, the total length of failure was 22 inches. The two other failures were 6 and 1½ inches respectively. The cracked shell plating was repaired by riveted butt straps and the cracked butt welds by welded straps, except those butt welds in which failure extended into the shell plating of the ship, these being repaired by a riveted strap. Straps were also welded on the butts of the keels of the other two ships and no failure has occurred to date, nor has any failure occurred in the tee welds on any of the ships.

(e) Joggled lap and butt strap joints were used on the British cross channel barge completed by the Admiralty in 1916, and lap, joggled lap, straight tee and butt strap joints on the British ship *M. V. Caria, ex-Fullagar,* launched on February, 1920. Reports to date indicate that joints are in good condition.

Conclusions

The full strength of the plate cannot be taken advantage of in riveted construction, due to the fact that the maximum efficiency of a riveted joint is only 89 per cent, as given in the U. S. Navy Department's specifications, and that the seams open up at much lower efficiencies, permitting water to enter between the faying surfaces. If the non-rigid type of metal arc welded joint is used in the same class of material, an efficiency of 100 per cent can be secured and joint is tight up to its ultimate strength.

It will not be very long before ship designers, and designers of structures in general, will be forced to recognize the great savings in weight of material, and costs of construction that are possible by means of metal arc welding, and that the welded structure is vastly superior to any riveted structure that can be built, as it can resist collision very much better, upkeep costs are reduced to a minimum and its life probably longer.

In order to secure the foregoing results it is necessary for the designer clearly to understand the fundamental principles involved in the design of welded structures, foremost among which are the laws of residual stress.—*Reprinted from Marine Engineering and Shipping Age, August,* 1924.

A WORD OF CAUTION

In The Gas Products Association Bulletin No. 28 the following item is given, which should be of interest to all concerned in the welding industry. It is a letter from a member of the G. P. A. to the association.

"Some time ago we recived a meter for measuring oxygen. As is customary in our plant here, we always examine very thoroughly any new apparatus, for oil or other combuustible materials, and found that in the inside case of the meter there was considerable paint and varnish; also dried red lead had been used. We took this matter up with them and pointed out the hazard which would be involved in the presence of such materials in an oxygen atmosphere, and their letters indicated that they were not aware of the seriousness of these hazards.

"They showed a very open mind and a desire to learn further the point of view relative to these hazards, making inquiry at the same time as to whether mineral oil instead of linseed oil paints would be safer, or vaseline, showing that they did not appreciate the chemical conditions involved. We wrote them fully in the matter and covered carefully these various points.

"The thought occurs to us, however, that this would be an illustration of an easy method for trouble developing in an oxygen producing plant by the installation of a meter or any other apparatus without careful inspection, and particularly in the case of new plants where the management might not be closely in touch with each individual operation or might not even be aware of the possibilities that existed."

WELDING GASOLINE TANKS

An increase in production of ten times the footage per hour and large cost savings were the result of the adoption of automatic arc welding by the Wayne Tank & Pump Company at Fort Wayne, Ind., in assembling underground gasoline tanks. Previous to the adoption of arc welding, the tanks were welded by oxy-acetylene gas.

These tanks are made from ⅛ inch galvanized sheet iron cut in three sections, with the assembled tank having three seams each 120° apart and 116 inches long. The circumference of each tank is 118 inches. For the assmebly of the tanks, an automatic arc welder built by the General Electric Company was installed. This automatic machine consists of a framework for holding the tank in position and for carrying the automatic welding head and electrode supply. The joint to be welded is placed between two clamping bars and a backing-up bar. Along this seam travels the automatic welding head which feeds the electrode wire to the arc.

The procedure of welding is to tack each of the longitudinal seams at either end by acetylene, each of these two tack welds being approximately 3 inches long. The plates are placed about ⅛ inch apart before tacking, but draw up tight when the gas is completed. Following this, they are placed on the automatic forms and the arc struck at one end allowed to continue without breaking to the opposite end. Then the clamps are released and the tank rotated one-third of its circumference to the next seam and the automatic head welds the next seam on its return. The clamps are again released and the tank rotated to the third or last seam which is welded in the same manner as were the two previous seams.

RIGID AND NON-RIGID WELDING

By S. M. Miller*

THE need for defining at the start the meaning and scope of the subject seems evident. Both flexibility and rigidity are used in different senses, and in whatever sense they are used they are only understandable, except in pure theory, when they are used as comparative terms.

Rigidity means, in its fullest sense, that property of a substance which prevents it from being changed in form by any applied force either internal or external. A perfectly flexible substance is one that can offer no resistance at all to any force. Our experience shows that no such substances exist, and so we must content ourselves with using familiar materials as instances of what we mean.

As we are by our subject confined to the consideration of welds, we are thereby also limited to the consideration of metals. We well know that a thin sheet of almost any rolled metal is flexible; that is, it can be easily bent. Whether it will return to its original shape after bending is another matter.

It is evident that a piece of steel .01 inch thick and 4 inches square can easily be bent by the fingers, but that a piece 1 inch thick and 4 inches square cannot. On the other hand, if the 1-inch piece were 30 feet square and we could lift one edge, it also would be flexible; that is, it would bend easily.

We must, therefore, limit our subject in such a way as to make comparisons possible. As I see it, what is really meant by our subject is, should a weld have the same degree or a different degree of flexibility as the piece in which it is made.

It seems obvious that the ideal weld is one which has exactly the same physical properties as has the piece in which it is made, whatever these may be. But we know from experience that it is unusual to get this result.

A weld is a casting, and the same properties cannot be obtained in a casting as in a forging. The cooling rate of a casting made in a sand mold is different from that of a weld made in that casting, and this alone creates different properties. Differences in chemical composition between base and added metals is another fruitful source of difference in properties.

Everything considered, I know of no instance in which it is possible to obtain in a weld the same physical properties as in the base metal. In cast iron the weld is always stronger than the base metal. In soft steel the ductility is always less, and the strength usually lower. In brass and bronze the conditions vary greatly as to the strength and ductility of the base metal, so that it is not possible to generalize as to the relative physical properties of base metals and welds.

We can, however, go so far as to say that, as a usual thing a weld in wrought metal has less elongation and reduction of area than the base metal, largely because it is a casting. In cast metals the properties of the weld are usually more nearly those of the base metal, though never exactly the same.

In any kind of joint it is desirable to have an efficiency of 100 per cent and it seems to me that since we cannot expect the same properties in the weld as in the base metal, the practical question is, what can be done to arrange matters so as always to avoid breaking in the weld in service, in cases in which breakage would be serious, and if this cannot be done, how far can we go toward accomplishing it? As an illustration, a weld made in soft steel plate with ordinary low carbon wire, a very common combination, has usually less tensile strength per square inch of section than has the plate. We can increase the total strength of the weld by increasing its sectional area or, as we say, reinforcing it. This is especially true if the weld be of the double V type. But if the plate be of, say, 60,000-pound tensile strength, it is not sure that this increase will make the weld stronger than the plate. Also the strong plate puts stresses into the weld, which may be dangerous in service.

We can help matters much if we insist on using plate of less tensile strength, which is more ductile, so that the weld will be stronger than the plate, and, therefore, the stress distributed over the plate and not concentrated in the weld.

Evidently the same result can be obtained by using suitable high tensile strength welding material with the high tensile strength plate. But here the effect of the heat must be more carefully considered, as a very high carbon plate may be so damaged by the welding as to make it weak and brittle.

Again it is becoming very common to weld cast iron with bronze, and many jobs can be done this way that can be done only with difficulty, if at all, when using cast iron welding rods. The bronze weld does not have anywhere nearly the same physical properties as the cast iron. Its tensile strength is much higher, its ductility is greater and it has a very elastic limit. The last property makes it unsuitable for any part that must not give under stress, such as a stamping press frame.

I do not think that we can say categorically that a weld should be either rigid or flexible, as we are limited not only by the qualities of the base metal, but by the possibilities of welds. About as far as we can go is to make certain statements as to what we are able to do or as to what will be suitable in any specific case. We should, however, always have before us the importance of making a weld having the same physical properties as those of the base metal, and one of our principal objects should be to learn how to do this.

Research Engineer, Union Carbide & Carbon Co. Laboratories.

DISCARDED WINDSHIELD SAVES DOCTOR BILLS

By Oscar C. Palmer

In grinding cast iron it is found that the bits of casting and emery leave the wheel in a red hot state. Sometimes these particles lodge in the operator's eye and cause severe pain, not to mention the expense incurred by a trip to the eye doctor. To get away from this trouble, we took an old, discarded windshield frame, cut a piece out of the center and welded the two end pieces together. By using a part of the glass we had a short windshield about 12 inches long and 8 inches wide with frame on three sides. The open part of the glass is left on the side on which the operator does the grinding. In this way the frame does not interfere with the operator's vision of his work. On all of the windshield frames there is a bracket or bolt on either side and these can easily be used to connect the shield to the grinder. In order to accomplish this we used a flat piece of metal ¼ by 3 inches wide and of sufficient length to cover the wheel and about one-fourth way around in back. We connected this to the grinder and it made a very substantial frame upon which to fasten the windshield. We have had this in use for two years and as yet have not broken the glass and what is more important, we have not had to send any of our men to the doctors to have the particles of emery or metal removed from their eyes.

WELDING SOCIETY ISSUES FIRST DIRECTORY

As a sort of celebration of its fifth anniversary, the American Welding Society, 29 W. 39th St., New York, will publish its first membership directory. The entire editorial section of the August issue of its journal will be devoted to this purpose. In connection with the collection of data for its directory, a membership drive is under way to bring the total number of members up to 1,000. The directory will be the first important compilation of welders and it is hoped by means of the membership drive to make it as complete and up to date as possible in every particular.

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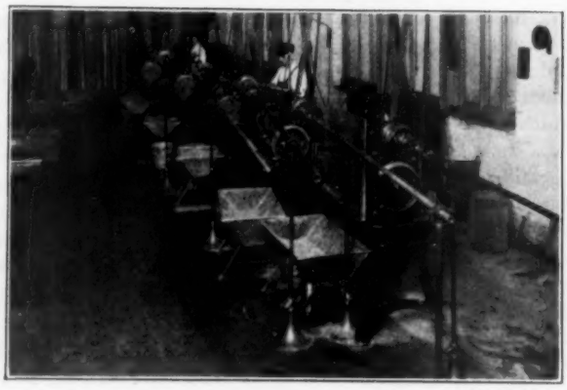

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ARC WELDER AND ITS USES*

Electrical Circuit—The Electric Arc—Utility for Welding Purposes—Electrodes for Arc Welding

THE path over which an electric current flows is called an electrical circuit. A given point in an electrical circuit is positive with respect to another point when the direction of flow of current is from the first point to the second. The intensity of pressure of the electric current is expressed in terms of volts. The rate of flow of current in the circuit is expressed in terms of amperes. In a direct current circuit, or, as it is sometimes called a continuous current circuit, the product of the volts and the amperes in the circuit represent the amount of electrical energy flowing. The product of the volts and the amperes in the circuit, together with the time of flow represent the watt hours of energy expended in the circuit. Electrical energy is usually expressed in kilowatt hours. Each kilowatt is a unit of one thousand watts.

As an example of this sort of calculation the voltage across a portion of an electrical circuit may be taken as 50 volts and the current flowing in the circuit as 600 amperes. The amount of power being consumed in the circuit is 30 kilowatts, or 30,000 watts. If the circuit is maintained for half an hour 15 K. W. hours of electric energy wll be expended.

The efficiency of an electrical machine is ordinarily taken as the ratio of the output of the machine to the input. If an electric generator has an output of 30 K. W., but requires an input of 50 K. W., the efficiency would be taken as the ratio of 30/50 or 60 per cent.

The Electric Arc

An electric arc is an incandescent stream of metallic vapors which carry an electric current. An electric arc is formed when two conductors of an electric circuit are brought together forming an electrical contact, then separated and there is sufficient voltage available to maintain the current of electricity through the intervening gaseous medium. Arc phenomena vary widely as the voltage between the conductors is increased. No attempt is made in this discussion to deal with high tension or high voltage arcs.

In a continuous current arc the conductor from which the current flows is called the positive electrode or anode. The conductor to which the current flows is called the negative electrode or cathode. The heated gases are sometimes called the arc flame.

The arc being part of the electrical circuit is subject to the same fundamental law. The product of the voltage across the arc and the current in amperes flowing in the circuit represent the amount of energy present in the arc. By introducing the time element the amount of power consumed by an electric arc can also be calculated. Thus, a 40-volt, 300-ampere electric arc used for one hour will consume 12 K. W. hours of electrical power.

The relationship between electric energy and heat is:

One K. W. hour equals 3413 B. T. U.

From this it will be noted that an electric arc may be considered as a transformer of electrical energy to heat.

The distribution of heat in an electric arc depends upon the density of current in the electrode. At the densities used in welding practice from ⅔ to ¾ of the total amount of electrical power converted into heat is expended at the positive electrode at the point at which the electric current passes from the solid medium of the electrode to gaseous medium of the flame. The balance of the heat is produced in the arc flame and on the negative electrode.

The area of the positive electrode from which the electrical current actually flows depends upon the amount of current flowing in the circuit and the atmospheric pressure surrounding the arc. At atmospheric pressure the arc is confined to a relatively small area. Since the total amount of electric power transformed into heat is relatively large the heat is of great intensity or temperature. The atmospheric pressure being approximately constant the temperature of an electric arc is for all practical purposes constant. While no attempt has been made to reduce the temperature of the arc by reducing the atmospheric pressure, research in this direction is being undertaken. Temperature of the arc and the amount of heat transformed from electrical energy by the arc should not be confused. The amount of heat in an electric arc may be practically anything, but the temperature, whether the amount be large or small, is the same for any given positive electrode.

Utility of the Electric Arc for Welding Purposes

The high temperature of the electric arc makes it valuable for welding purposes because any metal which is to be welded can be melted by the arc. Another important feature of the arc for welding purposes is that the large part of the heat is produced in the positive electrode where it will be most effective for melting the metal. Where metal is melted for welding purposes by a combustion flame the heat is always produced external to the metal and merely blown on to the point where molten metal is desired. Thus, in carbon electrode welding of steel where an arc is drawn between the carbon electrode and a piece of steel a large part of the heat is produced in the steel and such metal as is to be added is fed into the arc in the form of a filling rod. In metal electrode welding on the other hand, the metal to be added is made the negative electrode. The negative electrode is in the form of a melt bar, rod or pencil and is melted with such heat as is ordinarily produced on the negative electrode, together with the heat coming by radiation from the positive electrode.

The high thermal efficiency of the electric arc for welding purposes due to the fact that the heat is produced largely in the metal of the positive electrode is from 3 to 10 times the thermal efficiency of a combustion flame used for the same purpose, owing to the fact that in the combustion flame a large part of the heat is wasted by conduction and deflection of the flame from the point at which molten metal is required.

Electrodes for Eletric Arc Welding

Where the carbon electrode is used for welding purposes it has been found that the graphite electrode is distinguished from the hard carbon electrode, yields longer life than any other.

The current density used in an electrode depends largely upon the character of work done. It has been found that high current density in a carbon electrode adds to the stability of the arc and makes it more easy for the operator to control. On the other hand, a low density in the electrode means longer life and less heating of the electrode holder.

The table given below gives probably the average of the current values used on the various sizes of carbon electrodes for cutting and welding purposes.

⅛ inch diam.	75-amperes
¼ inch diam.	100-amperes
⅜ inch diam.	200-amperes
½ inch diam.	300-amperes

**Written for The Welding Encyclopedia by R. E. Kinkead, with additions by the Editors. Taken from the Fourth Edition of The Welding Encyclopedia.*

¾ inch diam.....400-amperes
1 inch diam.....600-amperes

In metal electrode welding a very wide variety of metal electrodes is used. Practically any standard brand of dead soft iron or low carbon steel welding wire (with a low percentage of impurity can be used provided it is given a coating which has a suitable alkaline base. There are a number of different trade names which apply to dead soft steel wires, which can be used satisfactorily in the metal electrode process, without any coating. Whether the wire is coated or not, the results obtained are very nearly the same, but for careful work there are many operators who show a decided preference for the coated wire.

As the percentage of elements such as carbon, manganese, nickel, etc., are increased in the welding wire the tendency is to increase the tensile strength of the metal in the weld. However, in bare wire welding, there is certain to be a difference in the material added depending upon what the original analysis of the electrode might have been so far as ductility is concerned.

The use of electrodes having high percentages of the above mentioned impurities is extremely difficult where the electrode is used bare. The difficulty in using electrodes of this nature arises from the fact that the metal is extremely "wild" in the arc while it is being melted.The addition of a lime, or other covering of similar nature, to such electrodes contributes materially to the success of the operation.

The use of covered electrodes permits the use of the alloy steels for metal electrode welding. Under certain conditions the use of the covering on the electrode will give an appreciable degree of ductility to the metal deposited by the electric arc welding process. The presumption is that this is due to the fact that the oxygen and nitrogen of the atmosphere is to a certain extent excluded from the hot metal during the welding process.

Covered electrodes are of two general classes. The first class being the electrode which has a heavy covering of scientifically prepared slag which contains a deoxidizer and which most completely protects the molten metal from the action of the gases in the atmosphere. The second class of covered electrodes is the type which has a very thin covering on the wire. The attempt is made with the thin coverings to obtain the same results as far as protection from the atmosphere is concerned without the disadvantage of manipulating the heavy coating of slag during the welding operation.

The use of copper, nickel and bronze electrodes for special purposes has been carried out successfully with and without coatings.

The use of 12 per cent manganese steel as an electrode has proven successful either as a bare rod or using one of the several types of coverings. This electrode is always made positive.

The early attempts of welding with alternating current were most unsatisfactory for the reason that the sine wave current of the ordinary power line or power transformer would not lend itself to a stable arc. The gradual building up of current first in one direction, its decreasing and building up in the opposite direction with the subsequent passing through the zero value did not permit of a stable arc.

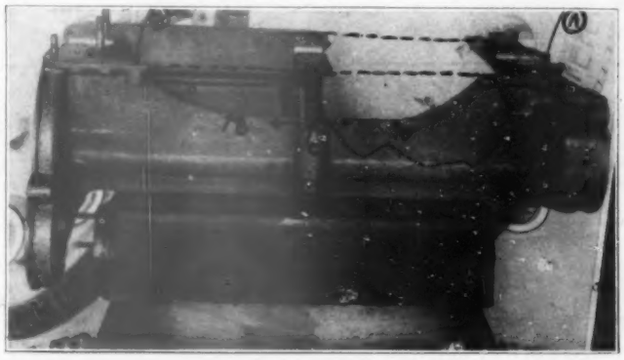
It was soon realized that special welding transformers had to be designed capable of producing a stable welding current. This was accomplished in two ways; by superimposing secondary windings, and by magnetic leakage as in the design of the constant current transformer producing a phase displacement and a lagging current.

This distortion of the sine wave resulted in prolonged maximum of both positive and negative current values with subsequent rapid changes through the zero value. This produced satisfactory welding current. The apparatus necessary, namely, the transformer, is a simple apparatus, requiring little upkeep expense. Its size makes it readily portable and it is economical in the use of current.

WELDING EIGHT PIECES INTO CYLINDER BLOCK

By C. E. Alexander

Here is how I welded an Oldsmobile cylinder block that came to my shop last week a bit the worst for unintentional wear. There were eight pieces to be matched up and replaced. These pieces were first matched, one by one, very carefully, on the welding table, then the finished single large piece was filed and ground around the edges to fit the space in the cylinder block. Invariably one large piece, so made up of several, is larger than the opening or space it is to fill. The final fitting must be snug and exact. All this work was done on the table. The crank case was then bolted onto both the block and the pieces with a thin rasher at "A" to allow a high enough surface on inserted piece so that it can be easily faced down to the original line with bottom face of the



Where Cylinder Block Was Welded

block. Two tacks were made at "B". The first one was cooled before making the second. The same procedure should be followed on the opposite side of the block.

The job was put in the furnace with the block in exactly the same position as it would occupy in the car. The actual welding of pieces began at "C", going two inches each way at a time until about half of the entire weld was made. Then the center cross wall was welded in place and the outside weld finished. The block was tilted on its side during the operation in the furnace, heat being maintained sufficiently to clean up the weld inside also. The main weld was done from the outside with enough penetration to assure a permanent job.

BENJAMIN G. LAMME WILLS SCHOLARSHIP

Two scholarships for the two most capable students in mechanical and electrical enginering courses at the Ohio State University were given by the will of the late Benjamin G. Lamme. Mr. Lamme was a prominent electrical engineer and chief engineer of the Westinghouse Electric & Mfg. Co. until his death. A fund of $15,000 has been given for these scholarships. They are to be awarded the winners during their senior year.

Mr. Lamme was a graduate of Ohio State University, to which he bequethed his life collection of Indian relics.

The will also provides for three funds each of $6,000 for gold medal awards. From one fund a medal is to be awarded to one of the graduates of the technical departments of Ohio State University for meritorious achievements in engineering or technical arts. From a second fund a medal is to be given to a teacher for accomplishment or actual advancement in technical teaching.

Other funds set aside for the Amerian Institute of Electrical Engineers will provide a medal for the member of that society for meritorious achievement in the development of electrical apparatus or machinery. Not more than $1,000 of these funds can be used in making suitable dies for the medals and the remainder will be deposited for interest. If the interest from the fund permits, two medals may be awarded during a period of one year.

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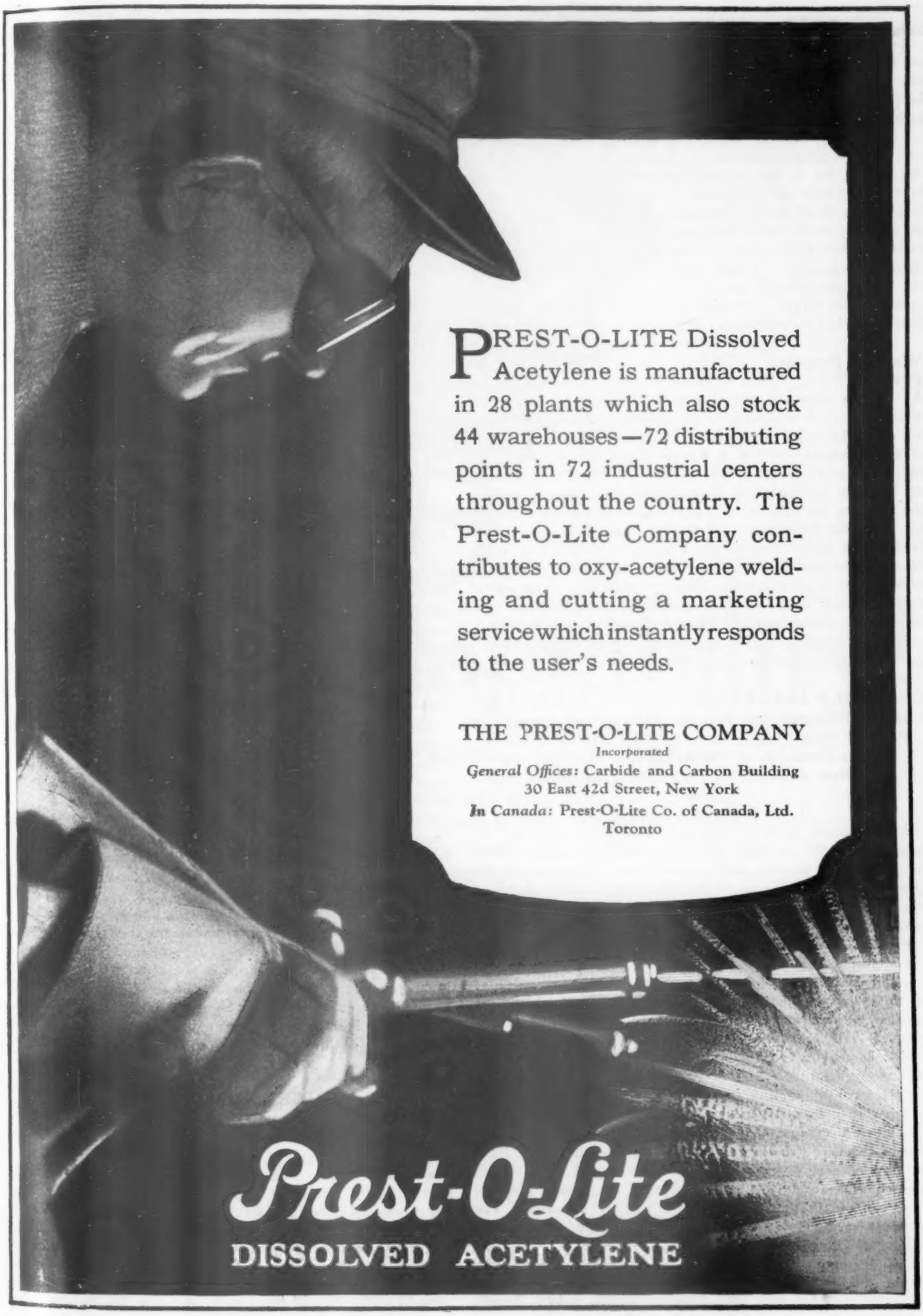
Welding and Limitations

AT present there are more limitations set on welding than are necessary. This is especially true in railroad work, where welding is very important and useful and could be made more so if given more of a chance. These limitations have been saddled onto welding because some railroads do not have the facilities for welding or the welding operators that the others have. This you can readily see gives rise to the thought that while one railroad could weld a great many things in an entirely satisfactory manner, it might be absolutely foolhardy to let some other shop which is not so well equipped or so well informed do the work. In the first place all would be well, in the second place it might be all right and again it might not. The railroads interchange a great deal of equipment and that is why they have set so many limitations on the application of welding. They have done this to safeguard their interests for while they would just as soon have their own shop turn out a certain job, they feel that their shop is the only place where such a welding operation can be done satisfactorily and they won't take the risk. This is holding back welding and something should be done to overcome this condition of excessive limitations. What can be done? It seems that the best and only thing that can be done is to study the situation very carefully and seriously with the idea of increasing the use of welding in railroad work and decreasing the limitations put upon it. This would necessitate a lot of work, and this work should be done by the various associations interested in welding. This sort of thing is being done by the Association or Railway Electrical Engineers. This association is preparing a manual on electric welding as used in the railroad shops. It will contain information which will be extremely useful and practical and should go a long way towards extending the use of welding in railroad work. While this will take care of the electric welding field, more work must be done. The gas welding field must be covered and enlarged. The American Welding Society has offered to aid in this work while the Gas Products Association, the Master Boiler Makers' Association, the American Engineering Standards Committee and the American Electric Railway Association will also do their bit towards extending the use of welding and its applications and reducing the limitations set upon it. We must all help if the art and science of welding is going to continue its sturdy growth.

Suggestions

IT IS always a very good policy to solicit suggestions from your men. These should be rewarded by the congratulations of the management or the man in charge, in addition to a suitable cash award. In many welding shops and other plants a system of getting suggestions and paying awards has been carried out with very excellent results. Not only does it stimulate an interest in the plant, but it also arouses an interest in the work the men do. After such a system is in operation for a short time this is very evident, for the men will be noticeably more interested in their work and not so interested in the time clock.

To inaugurate a suggestion system, post notices on the bulletin boards, or in conspicuous places, announcing that suggestions will be rewarded with cash prizes if they are accepted. Then put suggestion boxes at convenient points and have the suggestions collected and given over to a committee. This committee should be selected from among the officers of the company and should pass on the suggestions according to their practicability. In plants where a suggestion system has been in effect, reports show that for the first weeks the number of suggestions is large. After a while fewer suggestions are submitted. The number that come in during the first weeks usually contain a lot of things that are not practical and some that are extremely silly, while others would necessitate a larger expenditure for new machinery than would be practical or possible. Every suggestion should be seriosly considered and a letter of appreciatoin or con-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gratulation written to the sender, explaining why his suggestion is good or why it fails to win a prize.

Your men are working in the welding shop day after day on a given job or on a variety of welding jobs and they develop ideas that will save time and money. They should be rewarded in some way. The cash prize in a regular campaign does this very nicely. Then, too, if such a system is not in use the idea or the special kink or machine is often not brought into active use. It lies dormant in the mind of the welder, for he has no real incentive. But when he sees how he can cash in on his ideas it stimulates him, and makes him take a more definite interest in his work. These prizes do not have to be large, they may ordinarily range from five to twenty-five dollars, but in special cases where a new machine is designed or a new system completely inaugurated the committee should use discretion in making the award appropriately larger. This all brings about a feeling of good fellowship and co-operation. Try it out!

Welding Progress

PROGRESS in welding is shown by the development of new welding apparatus and machines. It is also shown by the wider application of welding to the building trades, to the plumbing contractor and to the building contractor. Wherever welding is wisely properly used, it is successful and time alone can tell to just what an extent it will develop. Limitations have been set upon the welding art in certain branches of industry, such as the railways, but these barriers are being broken down and welding is coming more and more into its own. It is now considered an art rather than merely a handy tool for repair work. In the radio field it is gaining steadily, in the aeroplane work it is used to a great extent. These are only two of the several extremely new fields in which welding is being counted upon to render a valuable service. There are many others. It is up to everyone interested in welding to point out its vast possibilities and its many applications in every field.

CYLINDER INSURANCE COVERS LIABILITY*

Liability Insurance for Personal Injuries and Damage to Property Now Hard to Get—Cylinder Explosion Insurance is Extension of Public Liability Insurance and is Now Available to Large and Small Manuturers.

By Clarence E. Cooper

All merchants, manufacturers and property owners are exposed to risks of loss from fire, theft, tornado, liability for damage to persons and property, and from many other causes, and the business of insurance has steadily followed the progress of commerce, so that today one can insure against most practical hazards. There are certain peculiar hazards inherent in some industries which require special consideration, and the possibility of a cylinder exploding with resulting claims against compressed gas manufacturers is one of these risks which the manufacturer realizes should be covered by insurance, and it has been our pleasure in developing this special form of protection (which is not included in the ordinary liability insurance policy) during the past ten years.

This form of liability insurance is not readily obtainable, as most Insurance Companies will not cover risks where the possibility of explosion is involved, but through the co-operation of the Gas Products Association and its members there are now several Insurance Companies who will write the insurance at a reasonable cost, and even the small manufacturer can obtain the insurance at a nominal premium. The premium varies somewhat, according to the kinds of gas, the volume of fillings, and certain other conditions.

Cylinder explosion liability insurance is really an extension of the public liability insurance usually carried and which covers against accidents occurring on the premises or immediately adjoining same, due to the business operations conducted at the specified locations. The ordinary public liability insurance does not, however, extend to cover the product of the manufacturer away from the premises and, therefore, the cylinder liability insurance is designed to protect the assured in the event of the explosion of a cylinder anywhere in the United States and Canada. It may be extended to include shipments of cylinders outside the United States. While the explosion of cylinders might be considered comparatively infrequent, considering the great number in use, and while the probability of the gas manufacturers being held liable in the event of personal injury or damage to property is problematical, it is nevertheless realized that such an occurrence will probably involve considerable legal expense, and most manufacturers accordingly carry the insurance. This, I would like to emphasize, applies not only to the high pressure forms of gas, but also to the low pressure forms. This is instanced by the case of an anhydrous ammonia cylinder which exploded while attached to the apparatus in the plant of a consumer, which resulted in the death of the Superintendent of that plant. Claim was made against the manufacturer of the gas, who also owned the cylinder, and a substantial payment was made to the widow in order to settle the claim.

The liability insurance policy covers in connection with the explosion of a cylinder, causing personal injuries. The minimum limits are $5,000 as respects injuries to one person and $10,000 as respects injuries to more than one person in any one accident. Higher limits may be obtained, however, at small additional cost, and are usually carried. The property damage insurance covers the manufacturer's liability in the event of damage caused to the property of others. The minimum limit under this feature is $1,000, although a higher limit is usually carried. Under both of these forms of insurance the Company agrees to pay the amount of any judgment up to the amount of the limits mentioned in the policy. These limits apply to each accident separately.

Until recently the insurance covered only claims arising from the explosion of the cylinder itself, but it has now been extended to include the explosion of any appurtenances or apparatus connected therewith and owned by the gas manufacturer while in use.

Some concerns feel that they want to protect their dealers in the event that any claim should be made against the dealer by reason of an explosion, and the gas manufacturer may, under his policy, include the interest of all dealers if he so desires.

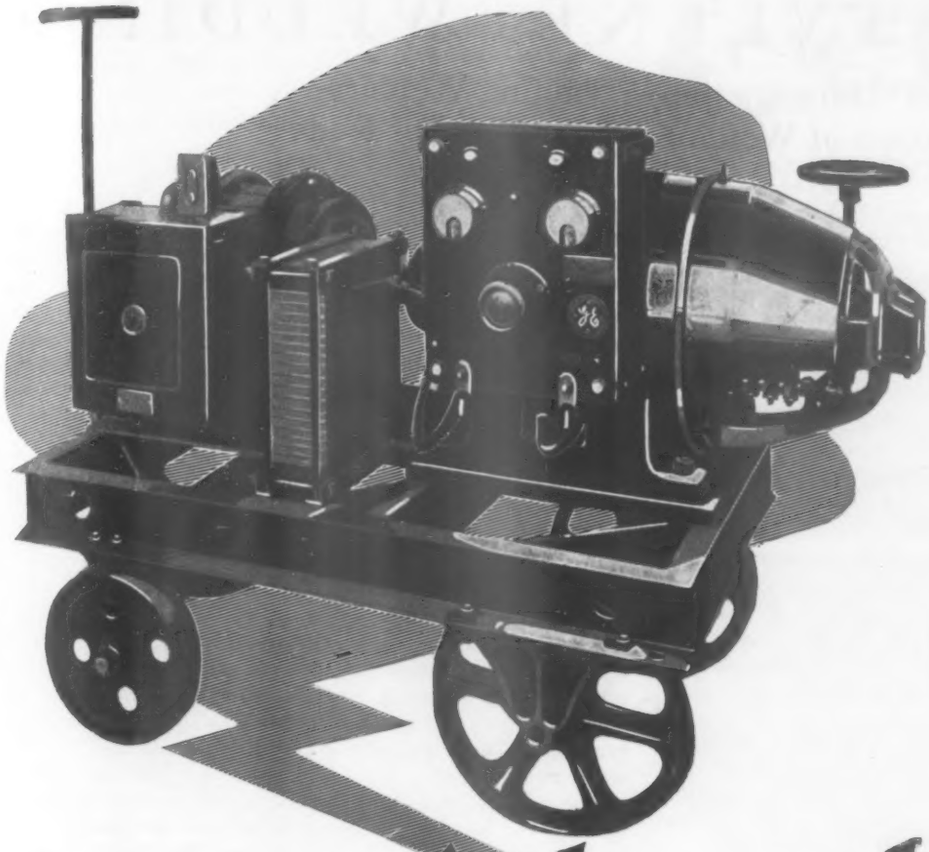
Another forward step in the evolution of this insurance which is of interest to many manufacturers is the extension of same to cover claims due to the consumption and use of the gas itself. This insurance is not a part of the explosion insurance, but if the manufacturer desires to be protected in case of any claim that may be made against him by reason of personal injuries or property damage due to the consumption or use of his product, that protection may also be obtained.

*Gas Products Association Bulletin 23.

CHARLES A. DUNCAN

The welding industry loses a progressive worker and builder through the death of Charles A. Duncan, who died on July 13th, at the age of 65. He was formerly president of the Great Northern Power Company and active in the affairs of the Zenith Furnace Company, The Duncan-Brewer Lumber Company, The American Exchange National Bank, The American Carbolite Company, as President, the Carbic Manufacturing Company, as Vice-President, and the Duluth Crushed Stone Co.

Mr. Duncan was born at Unadilla, Michigan, December 25, 1858. He left Michigan at the age of 21 for Duluth, where he has been a most influential and esteemed citizen.



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OXY-ACETYLENE WELDING*

Torch Manipulation—Training Welders—Selection of Welding Rods—Tests of Rods

OXY-ACETYLENE welds are accomplished by using a torch (or blowpipe) flame to heat the metal to be joined to the melting point. Usually some new metal is added from a filler rod which is melted at the same time and flowed together with the fused metal of the two edges of the joint. A high temperature flame (6300 deg. F.) is produced at the tip of the torch by the combusition of acetylene gas with oxygen gas. Oxygen is supplied compressed in cylinders, and acetylene is taken either directly from a generator or from cylinders. Between the gas supply and the torch each gas has to pass through a regulating valve which serves to reduce the pressure to that desired for welding and to hold it uniformly at that pressure.

To get the apparatus in working order, the regulators are first attached to their respective cylinders, and then the torch connected to the regulators by suitable lengths of hose. Oxygen cylinders should be "cracked" or in other words, the cylinder valve should be loosened in order to blow out any dust or dirt which might have been lodged in the nipple. This should be done with oxygen cylinders just before adjusting the regulators. As a general rule, the threads on the valves of oxygen and dissolved acetylene cylinders are different, but the proper regulators may be recognized by the high pressure gauges. Regulators should turn up close to the valve without the use of washers.

It should be remembered that the oxygen is under a high pressure, but if properly handled, it is harmless. The oxygen should be turned on from the cylinder. the valve being opened very slowly.

Stand behind the cylinder, with the spring tension of the regulator off and the valve on the welding torch open. If there is a shut-off valve on the torch, it should also be open.

Care should be taken to see that the regulators are tight on the tank and also that hose connections are tight. Also see that all connections are free of oil, grease or dust. Use a wrench to tighten these connections.

In setting up a new outfit, the hose should be blown out. Do this with oxygen, turning in the regulator adjusting screws just enough to permit the gas to flow through with some force. Very little gas is required for this. If acetylene is used for this purpose, very little should be used, especially in closed places. Torches should also be blown out, Oxygen should be used. Insert the hose in the torch head, with the needle valves open, and the flow of gas will clean the interior. Pressures are adjusted by means of the regulators and the acetylene gas turned on and lighted. The pure acetylene flame is long and bushy in appearance, getting shorter and more violent when the oxygen needle valve on the torch is opened.

As more oxygen is turned on a sharply pointed white flame is seen near the tip of the torch. This is known as a carbonizing flame, because all the carbon present in the acetylene is not being consumed. Increasing the oxygen flow reduces the sharp white flame to a small white cone. This is called the "neutral" flame, and is the flame most used for welding. A surplus of oxygen will cause the little white cone to shorten and be less clearly defined. This is the oxidizing flame, almost never used for welding purposes because the surplus oxygen burns the metal.

Parts are prepared for welding by beveling along the edges to be joined so as to give the flame a chance to penetrate to the bottom of the line of weld throughout its length. If no beveling is done a considerable separation between the edges is necessary to insure penetration. Before any metal is added from the filler rod the sides of the bevel are melted and run together, forming a "puddle" at the bottom of the V. The filler rod is then heated and introduced into the puddle so that the heat of the molten metal melts the rod and causes it to flow together with the parent meal.

Torch Manipulation

Some torch manipulation and movement of the welding rod in certain relation are absolutely necessary to sucess in oxy-acetylene welding. There are, however, no absolutely fixed rules for securing sound work. The torch may be actively manipulated while the welding rod is moved but little, or the welding rod may be the more active factor while the torch is held comparatively still. The result is practically the same in either case and between the two extremes is a variety of practices, one merging into the other imperceptibly. The theory of torch and welding rod manipulation is to distribute heat evenly on each side of the joint, to break down the walls and to secure thorough penetration and union of the adding material and parent metal. If the torch is active and welding rod passive the operator secures the desired result by heat action and gas pressure rather than by rod manipulation. If, on the other hand, he works the torch comparatively little but actively operates the welding rod, penetration and elimination of oxide are accomplished mechanically as well as by heat.

One secret of success when welding steel plates having a thickness up to 3/8-inch or more is to form a large puddle. The practice of many welders is to break the side walls in advance of the puddle for a distance of 1¼-inches to 1½ inches making sure that the metal is fused at the bottom of the vee. Then active puddling with the welding rod begins, the pool of molten metal being about 5/8-inch wide and ¾-inch long. The torch is whipped off the puddle from time to time. This causes the metal to "freeze" on the surface in semi-circular ridges.

To obtain the best results the following points must be observed:

The line of weld on the parent metal must be heated to the proper melting point.

The added material must be heated to the same melting point to prepare it for proper fusion with the melted metal of the work.

Added material must be added continuously at as nearly a constant rate as possible.

The melted portions of the added material and of the parent metal must be puddled together by proper manipulation of the torch and welding rod.

The puddle must be protected as much as possible from the air by the envelope of the welding flame.

The welding must include not only the center of the welding line but also a certain portion of the metal on both sides.

There must not be any reheating of the molten metal after it has had a chance to solidify, if this can be avoided.

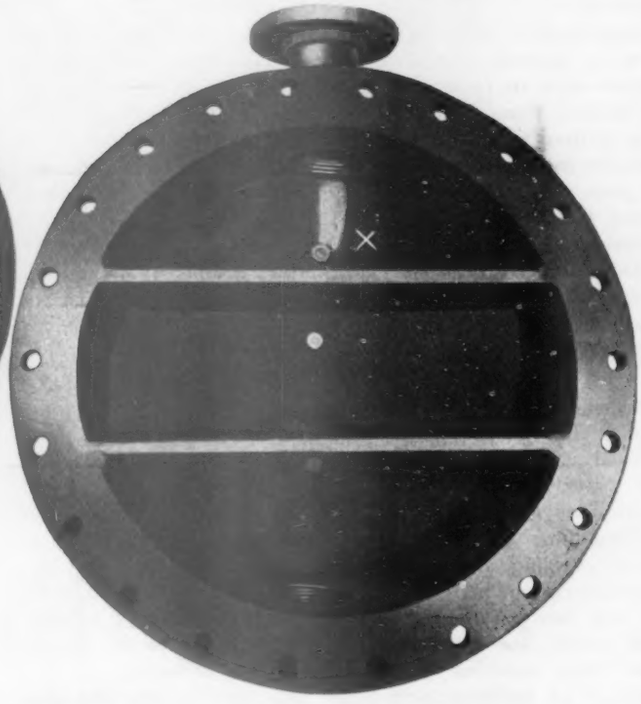
Separate adjustments must be made to suit all different conditions.

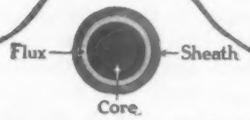
Training Welders

Naturally, a trade like oxy-acetylene welding in which so much depends on the personal education has drawn atten-

*Reprinted from the Fourth Edition, The Welding Encyclopedia.

~~CRACKED~~ but back in service in three hours





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THIS steam trap developed an outside crack near the manifold connection, and another inside farther down. Three hours after it reached the welder, live steam was passing through it.

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GENERAL ELECTRIC COMPANY, MERCHANDISE DEPARTMENT, BRIDGEPORT CONNECTICUT

tion to the need of training men to produce sound work. There are several methods of training raw labor to manipulate the welding torch. No doubt the best method is that which expounds principles and enforces practice in approved torch manipulation. Testing the welds is also a prime requisite in a training course. If a learner sees the inside of a defective weld made by himself, which looks fair on the outside, his conceit is taken down a bit. He learns rather painfully what to avoid. Manufacturing concerns must follow methods depending on the size of shop and class of work, however.

One concern starts off a learner with a cutting torch. The man is carefully instructed in its construction and manipulation—how to turn on the gases, light and adjust for the preheating flame and to turn on the cutting oxygen when the igniting temperature has been reached. After that he is allowed to play with the apparatus for a day or two when he is given some simple designs to cut out of sheet metal. When these have been successfully mastered he is given simple blueprints and told to cut out the designs, making his own measurements. This means training in other matters than cutting, and the new men soon acquire facility in the use of tools and acquaintance with shop practice, all of which has bearing on their success as welders.

After using the cutting torch for two or three weeks the men who have demonstrated that they have the qualities necessary for good welders are given welding torches and started at work on non-pressure apparatus, water tanks, and on water headers subjected to little pressure. From this work they graduate to ammonia apparatus. It is truly surprising how quickly some men master the principles of sound welding and become competent to do the most exacting work on high pressure ammonia parts. It is needless to say that anyone acquainted with oxy-acetylene welding will readily see that in such apparatus we have the highest and most exacting requirements. An advantage of this method of training welders is that each welder becomes familiar with the use of the cutting torch and uses it as an auxiliary tool to faciliate his work.

For instance, when making receivers of accumulators from standard lengths of lap-welded pipes, it may be necessary to cut a length of pipe into three or four pieces. This can be done in a well-equipped shop to advantage on a pipe machine, the bevelling being done at the same time. But in a smaller shop not so well equipped the cutting torch is used for cutting the pipe into lengths, having first marked the cut layout with chalk. The pipe resting on vee roller rests is slowly turned while the cut proceeds. When the welder has cut his pipe into sections he is ready then to weld on the heads and to cut the openings for nozzles, nipples and other connections. This work is done in proper sequence, the result being that the welder practically handles the entire proposition from the time the pipe comes into the shop until it leaves him to go to the testing station.

In a paper read before the International Acetylene Association, Mr. J. R. Dawson gave the following general considerations which will be helpful in the selection of filler material for oxy-acetylene welding:

Selection of Welding Rods

Unfortunately the practice has too often been to fill a steel weld with whatever steel rod happened to be at hand, or to weld copper with a plain copper wire, the general character of the metal in each instance determining the most convenient filler at hand, without reference to scientific balance of component elements. The results of such methods have frequently been disappointing.

A better procedure is to use a rod that will produce a joint as good as or better than the original or base metal. In this connection it is well to bear in mind that the metals joined are usually in the rolled or forged condition, while the metal deposited from the welding rod is in the cast condition. Very often a metal is of such composition as to possess excellent properties after forging and heat treatment, but in the form of the casting is of little value.

In order to obtain a high grade weld it is necessary to fuse the edges of the base metal and the welding rod at the same time, and to obtain an intermingling of the two metals. The product of this mixing may be entirely different from either of the original metals. This may be illustrated by attempts that have been made to weld cast iron with steel rods. The mixture of the metals at the junction is weak, brittle, hard to machine and lacking in the good qualities of either steel or cast iron. However, when the product is not required to stand severe strains or shocks there are certain instances when steel may be welded to cast iron.

The composition of the rod should be such that during welding the metal is not so liquid as to run easily over the unfused metal, covering up improperly fused and oxidized surfaces, nor should the melted metal be so viscous as to pile up and cause difficulty in obtaining a weld that is homogenous and smooth at the surface. A satisfactory rod will be sufficiently free from impurities and of such composition that the slag formed by welding will fuse and float readily to the surface of the molten pool. A very thin slag has the advantage of protecting the metal surfaces from oxidation, and when present in small amount is not readily entrapped in the weld.

Manipulation is easier and attended with greater success when the melting points of the rod and the metal being welded are approximately the same. Where there is considerable difference the low-melting-point overheated and damaged before the higher melting-point metal is fused.

This rate of fusion also makes important the exercise of care in choosing the size of rod and welding head for a given weld. The heat supplied should be sufficient to keep a small pool of molten metal in the weld and to melt in additional metal from the rod. If the rod is too large it will tend to chill the molten bath and may sufficiently lower the temperature to retard or virtually stop fusion of the rod metal into the weld. On the other hand, if the rod is too small it will not absorb the heat of the flame and pool rapidly enough, and the excess heat which results in the weld will burn the metal.

The usual method of manipulation is to melt a small pool of the base metal and then insert the rod in the molten pool. By this method the rod absorbs the heat necessary to melt it down and at the same time prevents the temperature of the molten pool from rising far above its melting point. The principle is the same that governs the temperature of water containing ice: It cannot be heated to a temperature higher than that of melting ice until the last of he ice is melted.

The torch is gradually moved along the weld and all slag is floated to the surface and laps or cold shuts melted out, the rod being kept constantly in the pool to supply metal for filling. Care is always exercised in manipulating the rod to avoid pushing the fused metal over the unfused metal.

The covering of unfused surfaces would produce the difficulty commonly called lamination, which is similar to the seams that sometimes occur in the rolling or forging of steel. This method of holding the rod suspended in the molten pool aids in the production of a clean weld, because it keeps the melting metal covered by the pool, prevents any oxidation below the surface, and makes it improbable that any oxidation or foreign matter will be carried to the interior of the weld. Furthermore, the neutral gases when directed at the weld adjacent to the rod, envelope both the rod and the bath in such a manner as to exclude atmospheric oxygen from the weld, so that excessive oxidation cannot occur when the filling rod and the blowpipe are properly manipulated.

Since the selection of the rod depends on the service re-

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TOBIN Bronze Welding Rods—an exclusive Anaconda product—are universally recognized as the most satisfactory non-ferrous rods for Electric and Oxy-Acetylene welding.

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In Canada: ANACONDA AMERICAN BRASS LIMITED, NEW TORONTO, ONTARIO

quirements of the finished weld, it may be well to consider briefly a few of the better known rods and the conditions under which they may be used to the best advantage.

The most important of the welding rods, if we judge by the quantity consumed, is Norway iron which, though really a steel, approaches closely to pure iron. A weld made properly with this rod will have a tensile strength of over 50,000 pounds per square inch and an elongation of from 25 to 3 per cent in two inches, thus combining high strength and excellent ductility.

The next in importance is the mild steel rod which contains 0.2 per cent carbon, and other elements in the usual percentage. Norway iron and this material may be used interchangeably, depending largely on the operator's preference. The mild steel rod ordinarily gives a weld of higher tensile strength but of slightly lower ductility.

High carbon welding rods are employed for building up worn shafting and for many other common uses where metal is required of sufficient hardness to resist wear and tough enough to resist shocks and other stresses. The carbon content of these rods may vary over a rather wide range, depending on the requirements of the finished welds.

Steel that has been subjected to mechanical work as in rolling or forging is strengthened by increasing the carbon content, but an increase of carbon in steel welding rods does not greatly increase the tensile strength of the resulting weld. This is due to the fact that the weld is essentially a casting and the weld metal forms in larger and weaker grains as the carbon content is increased, and to the added fact that welders have greater difficulty in obtaining sound welds with the higher carbon steels.

There are a few very skillful welders who have obtained excellent success with nickel steel welding rods containing 0.20 to 0.25 per cent carbon and 3.0 to 3.50 per cent nickel. Many other welders obtain poor results with this steel owing to cracks that form in a weld while it is red hot. The tendency to crack is due to the well known brittleness of nickel steel at high temperature. This property is illustrated by the difficulties so frequently encountered in forging nickel steel and by high temperature tensile tests showing that nickel steels, as compared with other steels, decrease rapidly in ductility at high temperatures.

Operators who are sufficiently skilled in handling nickel steel rods can make welds having a tensile strength as high as 60,000 pounds per square inch. This strength is greater than that of low carbon steel plate, such as boiler plate, for example, and when tensile tests are made the break does not occur in the weld, but generally several inches away in the plate metal.

High speed steel rods are rather widely used for making tipped tools. The high speed steel is melted into a slot cut from the end of a low carbon steel shank. After correct heat treatment the cutting qualities of the high speed steel deposited by the oxy-acetylene welder are as good as the high grade commercial brands of high speed steel. The melting causes very little change in the chemical composition, usually a slight reduction of the contained silicon and manganese, so the rods used should have about the same composition as a standard high speed steel. By using this process a heavy tool can be made up of inexpensive mild steel shank, and the small tip only of high speed steel. A wide variety of shapes and sizes of tools are thus made available without tying up an appreciable amount of money in costly material, as is the case when sold high speed steel is used. The requisite for success here, as with every high steel, is correct heat treatment.

Manganese rods are employed in the repair of machinery used for grinding and for other service where great resistance to abrasion is required. As previously explained, the manganese content of the rod should not be less than 14.0 per cent. Special precautions are necessary in welding this steel. The part to be welded should be supported so that the heated portion will be under as little strain as possible; it should be preheated to redness before the welding is begun and kept red hot during the operation. In this steel the favorable properties of great resistance to shock and abrasion are brought out by quenching in water from a temperature of about 1,800° F. In order to obtain the best results after welding, the quenching practice employed in manufacture should be closely followed.

One of the commonest of oxy-acetylene welding operations is the welding of cast iron. The expenditure of a few dollars for welding in this field may easily result in the salvage of a casting worth several hundred dollars. The composition of the rods used for this work is that of ordinary grey cast iron, the silicon content of which should be relatively high and the percentage of sulphur low. Excepting for certain special uses, grey cast iron is standard. Increasing the silicon content reduces the amount of carbon retained in solution during cooling, resulting in the deposition of a larger portion of it in thin graphite flakes throughout the cast iron. It is this structure which gives the fracture of grey iron its characteristic appearance. Grey iron is less brittle than white iron and is readily machined. When rods of correct composition are used the weld metal obtained is usually as strong as the original casting. The tensile strength of a cast iron weld is about 18,000 to 20,000 pounds per square inch and the transverse test of 1-inch square section using a 12-inch beam loaded at the center is from 2,000 to 25,000 pounds with the deflection of 0.1 to 0.15 inches.

Rods used for filling welds in copper are made of copper to which has been added a small amount of phosphorus as a deoxidizer. When hed hot, copper is readily attacked by oxygen, which has a very deleterious effect on its physical properties. Phosphorus arrests the absorption of these oxides into the weld, and for this reason copper should never be welded excepting with a filler rod containing phosphorus or some other suitable deoxidizer.

Very encouraging results are being obtained in the tensile strength of the welded metal. Indeed, it is felt that users of copper are not sufficiently aware of the advantages oxy-acetylene welding offers, and a great expansion of that field in the near future is confidently expected. Until recently only about 14,000 pounds per square inch tensile strength was obtained in copper welds, but improvements in rods have made possible the production of welds testing over 22,000 pounds per square inch.

Brass is successfully welded, rods of the usual brass compositions being satisfactory for this use. There is some loss of the zinc content—about two or three per cent escaping in the form of fumes during welding; and where much of this work is done proper ventilation should be provided to protect the workman from the poisonous vapor. A suitable flux is always used in welding on brass or bronze. The flux forms a thin slag coating over the weld, preventing oxidation and at the same time dissolving impurities and floating them to the surface of the weld.

The most popular bronze welding rods are the manganese and Tobin bronzes. They are used for welding bronzes and for building up worn bronze surfaces and also for brazing, which though really a soldering operation, is capable of effecting joints of great strength. A wide variety of metals may be joined by brazing. Among these metals malleable iron should be mentioned. Although welding destroys its good properties, very high efficiency results when a brazed joint is employed.

Aluminum welding and soldering by the oxy-acetylene flame has a widespread use both in manufacturing and in the repair of broken parts. The welding of broken crank cases is one of the regular services offered by most up-to-date automobile repair shops. Rods of pure aluminum as

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well as special rods of aluminum with zinc or copper additions are widely used and have met with much success.

Tests of Rods

Even though they may be of correct chemical composition, experience has shown that some rods are unsuited for welding. Any one of the manufacturing operations of melting, casting, rolling, cold drawing, etc., may not have been correctly handled, resulting in a faulty product. It is essential that the rods be made by good manufacturing practice.

Investigation of several curious failures of welding materials has focused attention on certain factors that as yet remain somewhat obscure. Welding rods are encountered occasionally that are not satisfactory in their welding properties, even though chemical analysis of the material shows that the proportions of the elements usually specified are correct.

Purchasers of rods may protect themselves by careful inspection and tests. Each grade of material should be tagged and given a distinctive marking, and the different grades should be kept in separate places, so that the mixing of the rods will be avoided. The surfaces of the rods should be free from lime or scale or rust. Among the impurities that rods may contain are slag inclusions, oxides and dissolved gases. Slag inclusions in the rod will be deposited in the weld and only with great skill and care will be floated to the surface. One of the most objectionable impurities in the welding rod is the aluminum oxide which results from the aluminum which is added to the steel as a deoxidizer during manufacture. While, if the manufacturing practice is right, it is not necessary to use sufficient aluminum to make trouble, an excess of aluminum resulting from careless manufacture is sure to present difficulties to the welder in the form of aluminum oxide. During welding the presence of aluminum oxide causes a granular appearing refractory slag to form on the surface of the melted metal, and difficulty is encountered in preventing some inclusion of this slag in the weld.

Iron oxide is readily dissolved in low carbon steel, and when present in the rod it can never be eliminated by the welding operation. Excessive oxides in the rod render it hot short, and their presence to excess may be detected by heating the rod to a bright red and bending quickly. A properly deoxidized steel rod will not break or crack from this treatment.

When due to faulty manufacture, dissolved gases are present in the rod or plate metal, they will be evolved during the welding process, and when the metal cools it will be left in a weak porous condition. A very satisfactory test of welding rods is to place several short lengths beside each other on the welding table and fuse them together. Then from other samples of the same lot build up the metal to twice the thickness of the rods. The workability of the metal may be observed, and the volume and character of the slag and any evolution of gases can be noticed. This test specimen should be broken and the toughness and ductility as well as the appearance of the fracture noted. These observations, together with those made during welding, should enable the purchaser of rods to know rather definitely whether or not the particular kind of rod thus tested is suited to his requirements.

TAYLOR SPOT WELDER

The Taylor Welder Co., Warren, Ohio, is now introducing a new spot welding machine to the trade. This new type N machine is built in three sizes for welding work ranging from No. 30 gauge material to two plates $\frac{5}{16}$-inch thick. The overhang is from 6 to 30 inches. The upper horn is adjustable in and out to permit the use of gooseneck welding points with one of the regular welding points, and both horns can be revolved in either direction. The lower horn is adjustable up and down and sidewise in either direction.

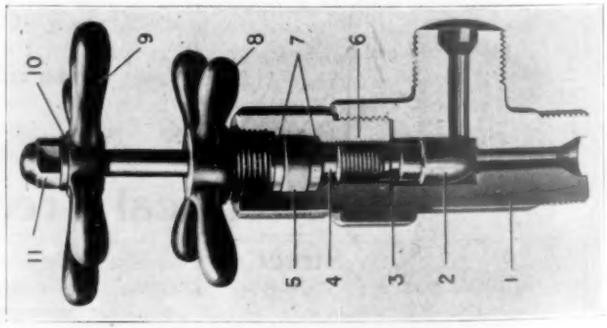
The smallest machine is equipped with a 10-kilowatt transformer, the intermediate with a 15-kilowatt transformer, and the largest with a 20-kilowatt transformer. There is an eight-step self-contained regulator for adjusting the current to take care of the lighest work up to the capacity of the machine. The switch is of an automatic and non-automatic type, so designed that it cannot close until the electrodes have made proper contact with the work. It is said that no adjustment is required for different thicknesses of work or for wear of the electrodes.

Taylor Spot Welder

The switch is changed from an automatic to a non-automatic trip by operating a lever. The automatic trip is desirable for welding work that is buckled and does not fit together properly, as it permits a positive pressure to be applied to the weld after the current has been turned off, and thus prevents the weld from separating while in the molten state. It is desirable to set the switch in the non-trip position in welding wire and clean sheets, and also in operations where greater speed is wanted. The pressure on the electrodes is controlled by means of a hand wheel. In addition to the water circulation in the electrodes the transformer is water-cooled. The machine may be furnished with a quick-change gear box and either a belt or motor drive. The foot-treadle is adjustable in or out and may also be swiveled to suit the convenience of the operator. The travel of the upper electrode and the foot tradle can be varied for different thicknesses of work by means of a lever which is located on the front of the machine.

NEW TYPE VALVE FOR OXYGEN MANIFOLDS

The Oxweld Acetylene Company, Carbide and Carbon Building, 30 E. 42nd St., New York, have made a study of several different designs of valves for oxygen manifolds.



New Valve for Oxygen Manifolds

As a result they have developed a valve which they believe meets every requirement. It has a swivel tip on the stem. The cross-sectional illustration shows the details of its construction and operation. The body (1) has a formed seat receiving the stem tip (2). This tip is attached to and carried by the stem (4), by means of a swivel joint. Thus it is

claimed, the tip is enabled to seek its own natural seat in the body. The stem screw is in the inner end of the stuffing box (6), which is made gas tight into the body by means of the lead gasket (3). The stem itself is made gas tight by the rubber packing (5), which is compressed between packing rings (7), by means of the hand wheel and nut (8).

A NEW PORTABLE WELDING OUTFIT

A new Portable Welding Outfit has been developed by the Lincoln Electric Company, of Cleveland, Ohio. They have combined the standard Fordson tractor with a specially designed trailer. This outfit furnishes both transportation and power for welding, and enables the commercial welder to go to any job where he may be called, whether in the factory or the yard.

New Portable Welding Outfit

The trailer is provided with carrying capacity for everything in the way of air compressor, gas bottles for cutting torches, and other things required on an emergency welding job.

A similar outfit has been in use in Pittsburgh for over a year, and it is claimed that it has travelled some 12,000 miles, mainly in the coal fields and the hilly region around South-eastern Ohio and West Virginia.

NEW MOTOR DRIVEN ARC WELDING GENERATOR

A new motor driven arc welding generator has just been placed on the market by the Allan Manufacturing and Welding Company, Inc., of Buffalo, N. Y. This is being marketed in conjunction with their line of welding transformers. It is a 120 cycle welding generator, which they say is suitable for any power installation. This generator is separately excited, having eight poles for 1800 R. P. M. and ten poles for 1200 R. P. M. Its frame is of cast steel with laminated pole pieces. Each pole piece is provided with but one coil, while all of the coils on the pole pieces are connected in series.

Allan Motor Driven Arc Welding Generator

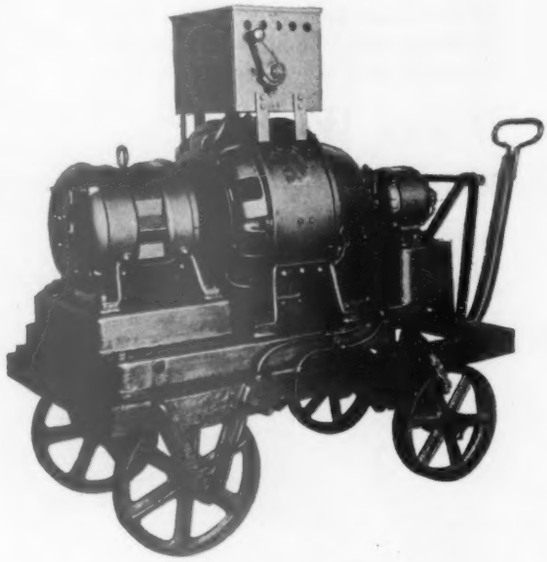
The armature is built up on a large diameter shaft and is carried on two ball bearings, while an extension of the shaft carries the exciter armature. Where the power supply is of the direct current type, the exciter is eliminated.

The generator can be driven by either belt, AC or DC motors, or by a gasoline engine. It is built in various capacities; the most popular size being the 4 KW set, which has a range from 50 to 200 amperes.

NEW WESTINGHOUSE SINGLE-OPERATED, 200-AMPERE ARC WELDING EQUIPMENT

The Westinghouse Electric and Manufacturing Company has recently designed a compact, entirely self-contained, single-operated 200 ampere arc welding apparatus which is available in either the stationary or portable form.

It is said the generator will deliver 300 amperes on intermittent work and that any welding current from 60 to 300 amperes may be obtained by operating the rheostat handle. This is conveniently located outside the control cabinet which is mounted on top of the generator. The 61 rheostat resistance steps enable the operator to obtain close current control if desired.



New Westinghouse Arc Welder

If an extremely high current is desired, the generators of several machines may be operated in parallel. The generator is designed to inherently stabilize the arc, thereby overcoming resistance fluctuations in the arc circuit, and, at the same time, eliminating the necessity for relays, solenoid controlled resistors, etc. Because of the special design of the generator, the operator can strike and maintain the arc, obtaining the necessary penetration and fusion for good welding. Any of the commercial sizes of metallic electrodes, from $\frac{1}{16}$ in. to $\frac{1}{4}$ in. in diameter may be used.

The generator and driving motor are mounted on a common shaft to which the exciter is coupled by means of a special flexible coupling. Ball bearings are used throughout to eliminate the leakage of oil when operated on inclined positions.

The driving motor is of standard Westinghouse construction and may be either a D.C type SK motor or an A.C. type CS squirrel cage motor, depending upon the character of the supply service. Alternating current driving motors may be used on 220 and 440 volt supply circuits by simply rearranging the lead connections.

Alternating current motors are started by connecting them directly to the line through a safety switch. Direct current motors are started by means of a type D starting rheostat. In both cases, all the operating mechanism except the handle is within the control cabinet, eliminating the danger of contact with live parts.

An ammeter and voltmeter—if desired—are mounted on the cabinet where they are readily observed by the operator as he adjusts the rheostat for current control.

The rugged construction of the unit makes it particularly adapted to railway shops, and such places where welding equipment receives rough usage. The truck is sturdy and is equipped with roller bearing wheels so that it can easily be hauled by one man.

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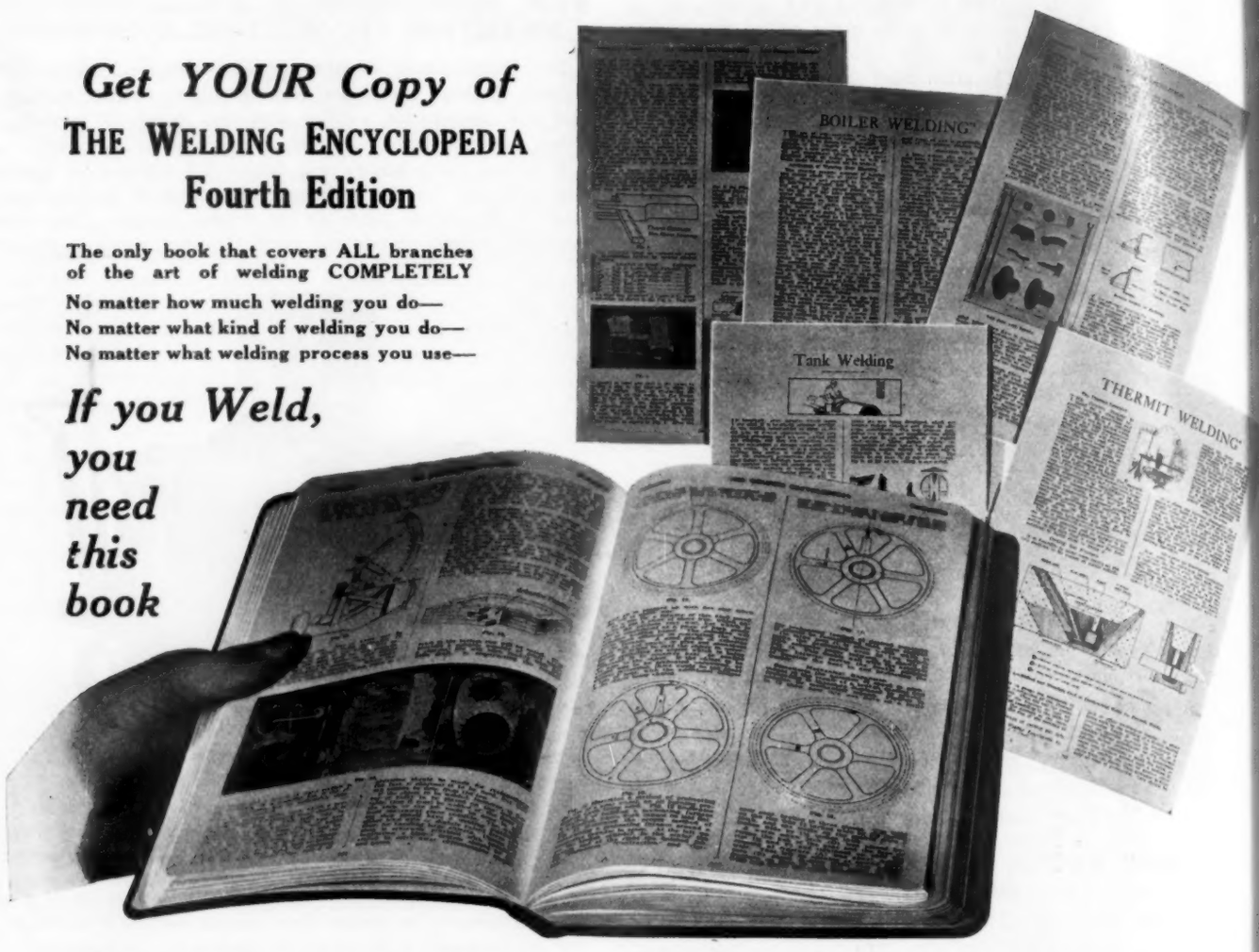


THE WELDING ENCYCLOPEDIA, Fourth Edition
COMPLETE—UP-TO-DATE—AUTHENTIC,
Expert advice at your finger tips

It serves every possible need for information on all of the welding processes. Whether your shop is engaged in production welding or repair welding, or both, whether you use the processes for only one metal or for a variety of different metals and different types of joints, The **Welding Encyclopedia** furnishes you with expert advice which pays for itself by increasing the quality of your work. **The Welding Encyclopedia** is not restricted to the welding knowledge that can be imparted by a single writer. On the contrary, each subject is discussed by a recognized authority on that particular subject. About fifty of the best known authorities on welding subjects in the world have contributed the results of their experience and research along special lines.

In compiling **The Welding Encyclopedia** the editors have had put at their disposal a vast fund of information which could not be made available through any other source. The result is a single volume covering the entire range of problems which can arise in the application of any of the welding processes, and this information has been so carefully arranged and cross-indexed that any portion of it is instantly located.

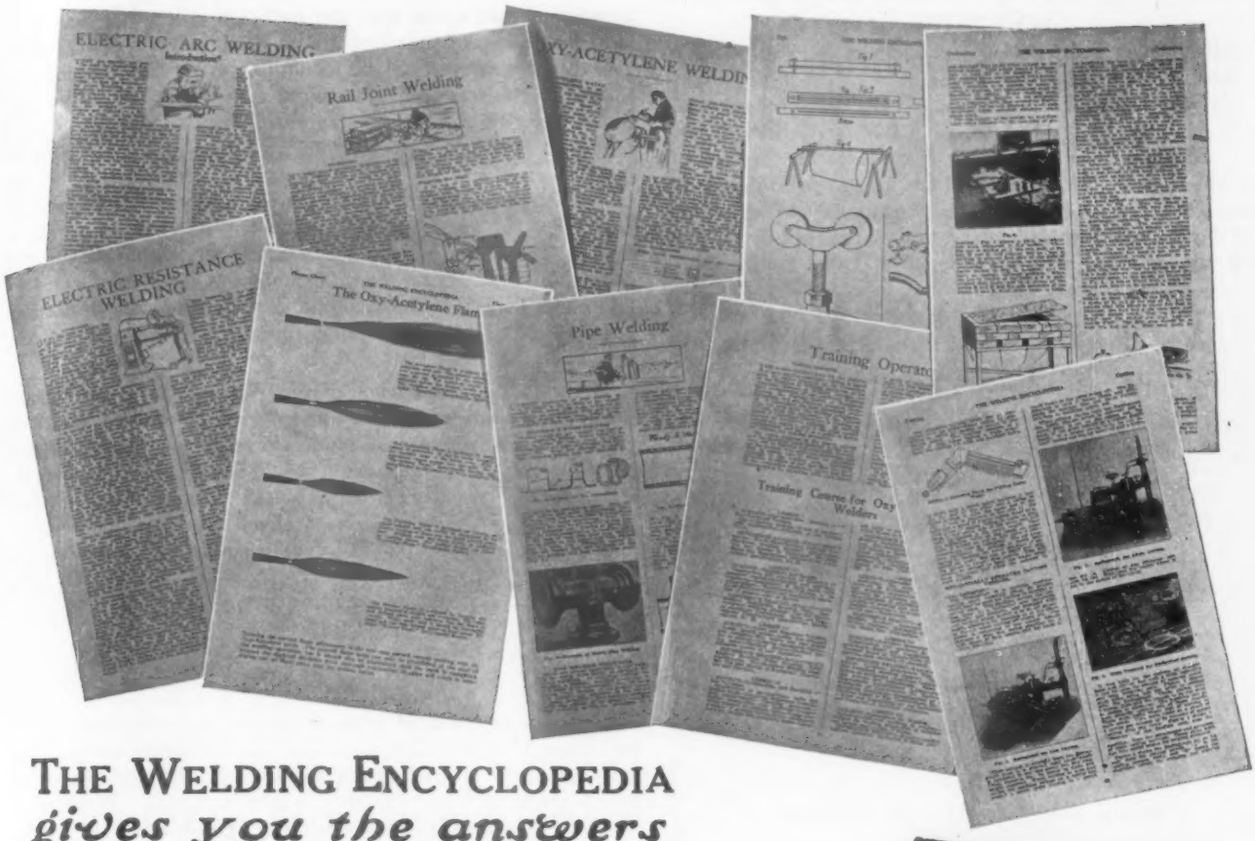
The Welding Encyclopedia describes in detail the theory and practice of every welding process, and tells how to weld every weldable metal by each of these processes, giving detailed instructions for handling such important welding jobs as boiler welding, sheet metal welding, tank welding, pipe welding, automobile welding, cutting, rail joint welding, railroad welding, etc.

It tells how to prepare parts for welding, how to preheat, how to anneal, how to test welds and how to select welding material. It explains the meaning of all words and terms found in welding literature. It gives the trade names of all products used in the welding industry, giving the name and address of the manufacturer in each case.

It tells how to take care of welding equipment so as to get the best results from it and keep maintenance costs down. It gives the latest revised federal, state and insurance rules and regulations for the installation of welding equipment, and its application to important work. There is also a splendid collection of charts and tables used for welding information, grouped together for convenient reference.

A valuable feature of The Welding Encyclopedia is the chapter on the training of operators. This chapter outlines lessons, exercises and examinations for a complete course in both oxy-acetylene and electric arc welding. Throughout these instruction courses references are supplied to the instructor and student so that they may find instantly the portions of the text which cover the topics in the outline.

The text is profusely illustrated with photographs and drawings made especially for **The Welding Encyclopedia**. No detail has been overlooked which could make The **Welding Encyclopedia** complete and practical.



THE WELDING ENCYCLOPEDIA
gives you the answers

The editorial office of The Welding Engineer is recognized as the headquarters for authoritative information and help on all branches of welding, and conducts a large volume of correspondence helping welders and welding departments out of their difficulties. In a period of eight months it was found that 95% of the problems submitted to this office were answered directly from the pages of The Welding Encyclopedia.

Think of the time all these welders would have saved by providing themselves with a copy of The Welding Encyclopedia in advance! Don't wait until you get into trouble, or run up against a hard welding problem, but get the information in your hands now. Then, when you want it, it will be instantly available.

Whatever your troubles may be, you will find that The Welding Encyclopedia furnishes expert advice and instruction.

The table of contents below can give you only a very general idea of the scope of this work. Send for the book and give it a careful examination. We guarantee that it will be fully satisfactory and if not we will cheerfully make a refund. Send the coupon today.

CONTENTS

1. Illustrated encyclopedia covering all words, terms and trade names used in welding.
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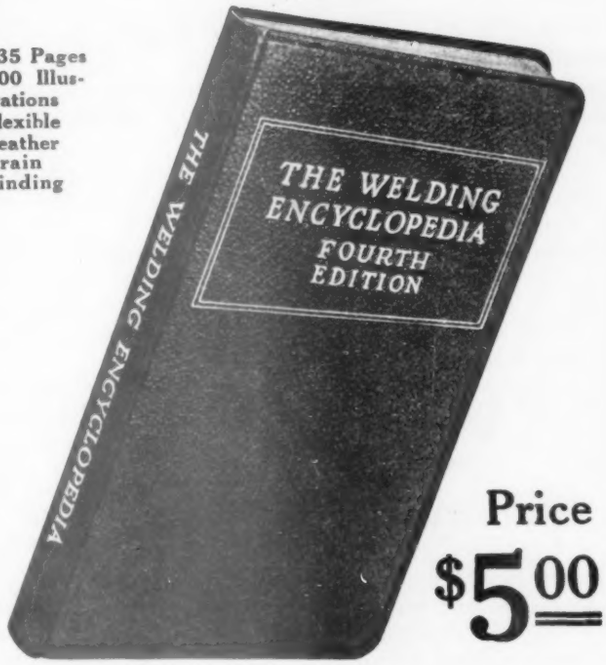

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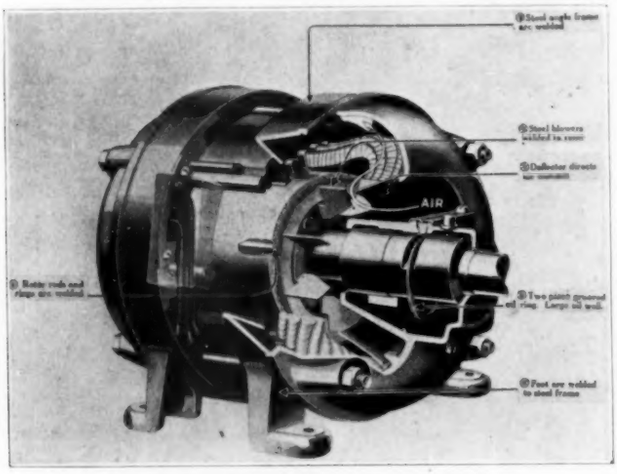
AN ELECTRIC MOTOR MADE BY ELECTRIC WELDING

An entirely new development has been made in the electric motor field by the use of arc welding.

In this motor the end is made by rolling a standard steel angle to circular shape, then joining the ends with the arc welder. The feet are drop forgings welded to the angle steel frame. The blowers for ventilation are welded to the rotor or armature by arc welding and lastly the copper rods or windings of the rotor are welded to the short circuiting rings, preventing any loosening or current leakage at this point.

The interest in this for most manufacturers is the improvement which has been made possible in design, while at the same time, reducing manufacturing costs.



Electric Motor Made by Electric Welding

Generally speaking the casting costs two or three times as much as the steel for the same part and is only about one-fifth as strong.

As an instance of this, the end frame being rolled from a standard steel angle is of much thinner section than the casting formerly required. This gives much more ventilating space between frame and coils and makes for better cooling.

At the same time, the steel frame can be hot riveted and be drawn up far more tightly without breakage, thus holding the stator laminations more firmly and producing a better electrical field.

The Motor is made by The Lincoln Electric Company of Cleveland, Ohio, who have applied arc welding in similar manner to the design of many products made of iron and steel.

THE TRIUMPH OF THE WELDED SHIP

By A. C. Blackall

The all-welded ship has proved, by actual experience, that a vessel so constructed successfully stands the test of stranding. The steamer is the "Caria," built by Cammell Laird & Co., on the welded system in 1920. She was inspected in her damaged condition by a group of eminent British naval architects and shipbuilding experts, who were delighted with her condition after the experience through which she had passed.

The vessel is of 398 tons gross register and stranded on a sand bank in the upper reaches of the River Mersey while en route from the Manchester Ship Canal to Belfast, Ireland, with a full cargo. She remained fast on the bank during the ebb tide, and at low water strained herself considerably, but owing to her particular type of build and the fact that there were no rivets in her, she remained absolutely water-tight during the whole of the period, although a considerable part of her length at the bilges was partly set up to the extent of about 14 or 15 feet.

On the next rising tide she was refloated and after being sounded it was found that she was perfectly water-tight, and she proceeded on her voyage to Belfast, where her cargo was discharged in excellent condition. After the discharge of the cargo she was again thoroughly examined, and still found to be water-tight. It was, therefore, decided that she should return to England, but as a precautionary measure a salvage pump was placed on board in case of necessity. She duly arrived back in Liverpool, the salvage pump not having been required. The "Caria" subsequently entered Cammell & Laird's shipyard at Birkenhead and was drydocked on the following day. A thorough examination was then made of the whole length of the ship, and it was found that there was not a single break in the hull, although, as already stated, she was badly set up.

If the "Caria" had been of the rivetted class undoubtedly the rivets would have been opened up and sheared, and it is very doubtful whether it would have been possible to get her off the bank, as the seams would have opened up and the water entered the vessel. In any case she certainly could not have continued her voyage to Ireland.

The severe test through which this welded vessel passed demonstrates very effectively the triumph of the welding principle for ship construction.

WELDBAKK

Weldbakk is a new molding compound which is manufactured by Anson G. Betts, Kinderhook, N. Y. Weldbakk is shipped as a damp powder which must be moistened with water and worked into a thick, stiff, smooth putty before it is used. Weldbakk is molded to the work and dried to the desired shape. For instance, in preparing gear teeth a mold is made around a good tooth and when it is dried it is transferred to the missing tooth position where the mold is filled using the torch and filler rod.

ARC WELDING APPARATUS ORDERED BY SANTA FE RAILROAD

The Atcheson, Topeka and Santa Fe Railway System recently placed an important order for twenty-eight arc welding equipments with the Westinghouse Electric & Manufacturing Company.

These equipments will be distributed among fourteen of the Company's shops, from Chicago to the Pacific Coast. This order, one of the largest ever placed for welding equipment, is renewed evidence of the activity of the railroads in extending their welding facilities.

W. L. R. Emmet, an official of the General Electric Co., Schenectady, N. Y., has been awarded the degree of Doctor of Science by Trinity College in recognition of his research and achievements in connection with the mercury-vapor turbine and boiler. Professor Elihu Thomson, one of the founders of the General Electric Co., and director of the Thomson Laboratory of the company at Lynn, Mass., was awarded the degree of Doctor of Science by the University of Manchester (England) on July 14.

DEMOLITION OF BATTLESHIPS

Work of a very interesting nature is being carried on by the firm of Markovitz and Taylor at Oakland, California, where they are cutting down battleships for conversion into peace-time craft. Oxy-hydrogen torches are being used to dismantle the big ten inch and twelve inch guns of these boats and render them adequate for plough shares and other peace-time implements. Seven boats, all with histories antidating the Spanish-American war, are undergoing this demolition.

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News of the Welding Trade

Mr. J. R. Brant, of the Indiana Oxygen Co., Indianapolis, Ind., has just left for a trip to Alaska. He will be gone about eight weeks, and will go from Chicago to Seattle and then by boat to Cordova. When Mr. Brant arrives in Cordova, he intends to travel to Fairbanks, Alaska, going either by sleigh or automobile according to the amount of snow. From Fairbanks he will again travel across country to Anchorage on the coast. After seing the sights of Anchorage, he will again embark and go by boat to Kodiak Island, which is famed as the island of a "thousand smokes," so called on account of its great number of active volcanoes.

The Mosebach Electric & Supply Co., 1115 Brownsville Avenue, Pittsburgh, organized with $25,000 capital stock, is engaged in manufacturing weld test bond and arc weld rail bonds for street railroads, mines, etc. It also carries a stock of street railroad material, brass and bronze bearings for locomotives, mining machines and street cars. Plant and equipment are adequate for present needs. K. J. Mosebach is general manager.

The General Electric Co., Schenectady, N. Y., is continuing its establishment of service shop and repair divisions at its various branch factories with the latest shop to be located at Kansas City, Mo. Arrangements have been made for similar machine departments at Lynn, Mass., Oakland, Cal., Fort Wayne, Ind., Erie, Pa., as well as at the main Schenectady works.

The Westinghouse Electric & Mfg. Co. will enlarge its Mansfield, Ohio. works by the erection of two steel buildings, one four stories and the other one story.

The Magnolia Gas Co., Beaumont, Tex., contemplates the installation of two pumping plants for booster service at DeBerry and Pineland, respectively, in connection with its new 200-mile pipe line now in course of construction from northwestern Louisiana to Beaumont. Fred M. Lege, Jr., is president.

The Siemund-Seneca Arc Welder Corporation, 29 Broadway, New York, recently incorporated with $20,000 capital stock will manufacture welding equipment. W. C. Steiger, W. J. Metzger and W. Hedley are the incorporators.

M. D. Goodman, 185 Bigelow Street, Newark, N. J., is inquiring for lifting magnets, electric arc welders and electric hoists.

The Gibb Instrument Co., manufacturers of electric welding equipment, Bay City, Michigan, announce the appointment of Mr. D. A. Clements to represent them in Missouri and Southern Illinois with headquarters at 4167 Washington Ave., St. Louis, Mo.

The Acme Electric Welder Co., Los Angeles, Calif., manufacturer of electric spot welding machines, announces the appointment of the T. L. Knudtson Engineering Co., 184 West Washington Street, Chicago, as representatives for its line of spot welding machines in the Central States.

K. A. Hills was recently made manager of the Davenport sales office of the General Electric Company. This office covers a territory which includes a large part of the state of Iowa. Mr. Hills has been in the employ of the General Electric Company since 1910.

The Transportation Engineering Corporation announces that they have combined their office and warehouse at 909 East One Hundred and Thirty-fourth Street, New York City.

Mr. J. A. Dittmar of the Southern Welding & Machine Company sailed for an extensive trip to Europe on August 10th. While there he will study the new methods, ways and means of the oxy-acetylene welding process abroad. Mr. Dittmar expects to take a long needed rest at Baden-Baden to recuperate from a recent operation.

Classified Ads

Help Wanted—75c per line, minimum 4 lines.
Jobs Wanted—4 lines free.
Other Ads—$1.00 per line, minimum 4 lines.
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FOR SALE

Gibb Instrument Company, Arc Welder. Serial No. 534. K. V. A. Volts 220. Cycle 60. Secondary. Amps. 300. K. W. 7 5. Address D. D. Wessels & Sons Co., 1645 East Euclid Ave., Detroit, Mich.

Position Wanted—By young Englishman, 34 years old, with 20 years' experience, is desirous of permanently locating in this country as an oxy-acetylene and electric welder. Have good, all around experience in all classes of welding, such as crank shafts, cylinders, crank cases, boiler welding, etc. Can furnish the very best of reference of all kinds. Address 27, care The Welding Engineer.

Wanted—Arc welder for partnership with acetylene welder. Wonderful opportunity. No competition. Had successful welding business for a number of years. Glad to give full particulars. Address 30, care The Welding Engineer.

Wanted—Acetylene welder for work in Philadelphia, experienced on all metals. Full particulars in first letter. Hourly rate and names of employers for past three years. Electric welding knowledge helpful, but not essential. Expenses refunded if competent after three months. Address 31, care The Welding Engineer.

Wanted—Electric welder in Philadelphia, with cast iron experience. Full particulars in first letter. Hourly rate and names of employers for past three years. Acetylene welding knoweldge helpful, but not essential. Expenses refunded if competent after three months. Address 32, care The Welding Engineer.

For Sale—One pistol Grip Smith with complete set of tips in fine shape, $22.50; one pistol Grip Smith complete with tips less cutting tip, $20.00; one large size Imperial with tips, $15.00; one medium sized Rego with five tips, $15.00; one Fidelity complete with tips, $10.00; one Oxweld Cutting Torch in fine shape, $40.00. Upon receipt of $1.00 any of these torches will be sent for examination. All torches in first-class shape. Address Spencer Welding Works, East Fifth Street, Spencer, Iowa.

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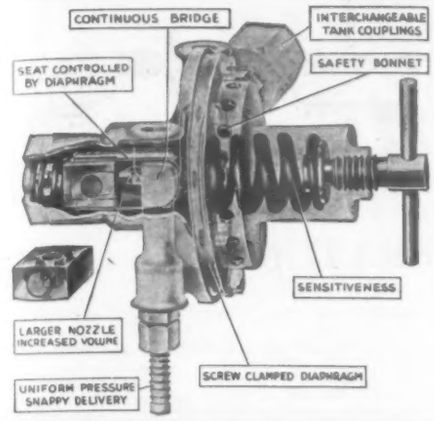

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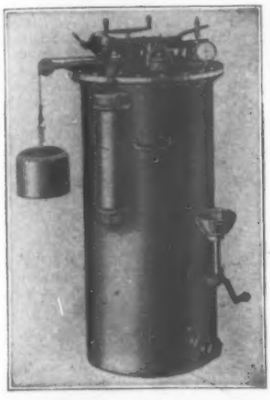

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For several years efforts have been made to draw up a Code for the Welding of Unfired Pressure Vessels. Opinions of the best welding experts were not in agreement on many essential points. Fundamental scientific knowledge based on test data was not available. The American Bureau of Welding has completed a series of tests on some 47 tanks. The program involved an expenditure of over $15,000. The test data, analysis of same, conclusions and recommendations to the Boiler Code Committee of the A. S. M. E. has been compiled in a report, copies of which are available for distribution at $1.50 to members and $5.00 to non-members.

American Welding Society

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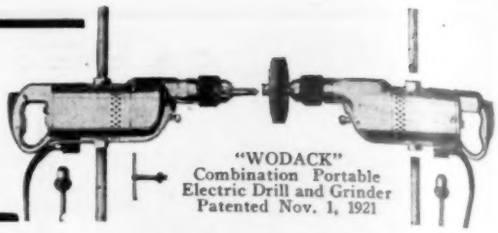

"WODACK" Combination Portable Electric Drill and Grinder Patented Nov. 1, 1921

CURRENT WELDING LITERATURE

ALL-STEEL TUBULAR WELDED STRUCTURES—Articles describing the steel tube fuselages used on various airplanes and the possibility that similar structures may be evolved for other purposes. On large tables on which the shapes of the sides of the structure have been drawn out, the tubes are cut to length and put together temporarily. They are held in position between angle irons and then point-welded. Fuselage sides are then removed and joints finished off. Cross-tubes are next welded in place and the small quadrants in the corners are inserted. The fuselage is then placed in a rigging jig, the double wires put in and tightened and the fuselage structure is finished.—Aviation, June 9, June 16, 1924.

WELDING OF MANGANESE STEEL, by S. W. Miller—A preliminary report of the Gas Welding Company of the American Bureau of Welding covering this subject. It takes up the composition of steel which is essentially an alloy of iron and carbon and gives the elements which enter into commercial use and the influence of manganese directly and indirectly on the strength of ordinary steel. Properties of ordinary carbon steel changed by heat treatment. Changes occurring during the freezing and cooling of steel. How various tests are made. Technique of welding. Heat treatment and microstructure of welds. Oxy-acetylene weld can be produced in manganese steel that is equal in quality of the base metal. Use of flame having slight excess of acetylene is not injurious. Powerful flame essential and large pool of welded metal must be maintained. Welding rod must not be rubbed in weld. Must be left in melted pool and under surface of liquid metal. Block up heavy pieces to avoid strain during welding or preheating. Care must be exercised in preheating. Apply same heating treatment for weld as for base metal. Throwing water on weld will not produce austenitic structure. Suitable flux will assist in making weld.—Acetylene Journal, August, 1924.

THE STATUS OF WELDING—In a recent issue of the Iron Age there was an editorial headed "The Status of Welding." It went on to say that in the past welding was treated as more or less of a fad by the editors and contributors, and that the news value of the stories began to wane. This was not due to the fact that the art or its commercial use had come to a standstill. In reality the conditions appeared to have been quite otherwise. Leading manufacturers of welding apparatus have been pushing an extensive campaign to extend the applications. This editorial goes on to say that it may surprise many to find out the welding processes have become far more than handy tools for repair work. Now their principal use is for routine manufacturing operations. Welding or cutting in some form is now in all branches of the steel industry, starting in the iron or steel foundry and going clear through to the manufacture of steel tubes and furniture. This editorial went on to say how welding has entered the steel and metal industry and the pipe line welding industry and that it is used for the manufacture of steel barrels, hot water tanks, small oil tanks, metal furniture, and sash and achitectural trim. It points out that the iron and steel industries have thus been given a versatile piece of equipment, which within the past few years has taken its place alongside the air hammer and the pipe wrench as a production tool.

VICTOR OXY-ACETYLENE EQUIPMENT COMPANY CATALOG NO. 20—The Victor Oxy-Acetylene Equipment Company, San Francisco, California, have just published a new catalog which they call No. 20. This consists of 32 pages on heavy enameled stock and bound in an attractive heavy paper cover. This catalog is very nicely printed and well gotten up, giving the complete line of equipment handled by the Victor Company. It is extensively illustrated throughout with wash drawings and line drawings.

LIQUID OXYGEN EXPLOSIVES IN EPOCH MAKING BLAST, by F. W. O'Neil—4,500 tons of rock lifted in Pennsylvania quarry with less than 800 pounds of the new explosive. Demonstration of liquid oxygen for rock blasting highly successful. New explosive known as Lox. Comparison of its cost with other processes. —Acetylene Journal, August, 1924.

MAINTAINING WELDING AND CUTTING EQUIPMENT—Setting up welding equipment. Regulators should not be attached to the wrong cylinders. Connect the hose line to the right nipples. Release the adjusting screws to not open cylinder valves quickly. Regulators are carefully made instruments. Insert the torch tip carefully. Test for leaks with soap suds. Use care in disconnecting equipment. Equipment does not receive sufficient care. Do not abuse torch while in operation. The cutting torch—Acetylene Journal, August, 1924.

AN INVESTIGATION OF THE FATIGUE OF METALS, by H. F. Moore and T. M. Jasper, 88 pages, 6 by 9 inches—Published by the University of Illinois, Urbana, Illinois as Bulletin No. 142 of the Engineering Experiment Station.

STANDARDIZATION OF PRACTICE IN DEMOLITION WORK, by T. C. Fetherston—Standardization of oxy-acetylene welding and cutting practice in demolition work discussed. Dismantling train shed in Pennsylvania Railroad Broad Street station in Philadelphia recently accomplished. How this work was done.—Journal of the American Welding Society, June, 1924.

BRONZE WELDING CAST IRON PIPE IN CHICAGO—This cast iron bronze welded gas line laid in Chicago street. Pipe is laid and lined up at side of trench on skids. Joints are butted together. Slight space being left between each length of pipe and Tobin bronze is used for welding. Bronze welding is accomplished by fusing Tobin bronze to the cast iron pipe in a band completely around the joint. Standard brass flux is used. Pipe is not cleaned unless covered with dirt. Test pressure 15 pounds per square inch. —Acetylene Journal, August, 1924.

WELDING PIPING IN BUILDINGS—Oxy-Acetylene process advantageous for welding piping in buildings in the construction. It is possible to weld pipes where pipe wrenches could not be used. —Oxy-Acetylene Tips, July, 1924.

REFRIGERATION PIPING FABRICATED IN THE SHOPS—Advantages of oxy-acetylene refrigeration engineer. How nozzles, nipples, brine tanks, cradles and fittings are welded—Oxy-Acteylene Tips, July, 1924.

THE SMALLEST WELDED JOINT BRINGS THE WORLD TOGETHER—Oxy-Acetylene welding used in making radio tools. Discussion of the use of this process in the radio field. Description of how the welding machine does this interesting work.—Oxy-Acetylene Tips, July, 1924.

OXY-ACETYLENE WELDING AND CUTTING EQUIPMENT—This is the title of the new bulletin published by the Oxweld Acetylene Company. It takes up in detail all of the equipment they manufacture for welding, cutting, brazing, lead burning, heating and decarbonizing. It is very well illustrated throughout and is well arranged and handsomely printed. It consists of 50 pages and is bound in a heavy paper cover.

THE UNLUCKY THIRTEEN—"The Unlucky Thirteen" is a booklet distributed by the Coast Culvert & Fluid Co., Portland (Kenton) Oregon. It consists of thirteen testimonial letters and a definition of economy. In the latter part of the book are reports of tension tests carried on by the Department of Public Works Testing Laboratory, Portland, Oregon.

THE PHYSICAL PROPERTIES OF MATERIALS—Strength and relative properties of metals and wood discussed in detail in the second edition of the Circular of the Bureau of Standards No. 101 published by the Department of Commerce, United States Government. This is a very complete treatise of the physical properties of all kinds of materias. It consists of 240 pages of text, diagrams, charts and tables, and covers the material question in a very complete and satisfactory manner.

WELDING EQUIPMENT IN A RAILROAD SHOP, by James S. Heaton—Modern welding equipment performs welding successfully in railroads shops. Acetylene equipment discussed in detail, goggles and safety equipment. Electric Arc Welding in the railroad shop. Discussion of electric flue welding, thermit welding. Jacks used when welding frames and structural work produce a solid weld by taking care of expansion. The use of sand blast.—Railway Mechanical Engineer, July, 1924.

STANDARD TIME FOR PRODUCTION WELDING, by Jos. W. Meadowcroft, Superintendent of Welding, E. G. Budd Manufacturing Company—This takes up the matter of setting a proper time limit on a given welding operation so that a piece work price can be set upon it. A proper time study of welding operation should be done by men thoroughly familiar with them. This gives efficiency and economy in welding. It raises quality of welds to high standard and also increases quantity of welds performed. In machine or automatic welding operations piece work prices can easily be placed on all work.—American Welding Society Journal, July, 1924.

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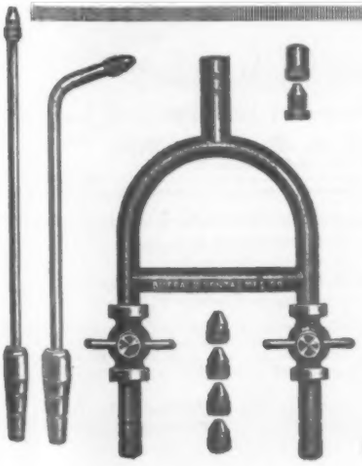

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A new mixing principle, a regulator that accurately controls gases, the greatest working range ever covered by ONE torch —are exclusive IMPERIAL features. Write for catalog.
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DAVIS-BOURNONVILLE COMPANY
was merged with
AIR REDUCTION SALES COMPANY
on March 17, 1922

The Oxyacetylene Welding and Cutting products formerly manufactured by Davis-Bournonville Co. are now made and sold by Air Reduction Sales Co. under the trade name of "Airco-Davis-Bournonville" or "Airco-D-B."

(See advertisement of Air Reduction Sales Co.)

Carbic

---AND CACTUS

Even if you do have to take your outfit way out where the cactus grows and where water is pretty scarce,—it matters little if you have a Carbic generator, for like the cactus, it requires but mighty little water.

Throw it on the running board of the car, with a drum of Carbic Cakes, and hurry away. Nothing to jar out of place or get out of order, and it's absolutely safe, no matter how you treat it.

All the way from the frigid zone of the north to the cactus covered areas of the south, the Carbic System is furnishing a reliable, safe and economical source of portable acetylene to thousands of users.

Let us tell you how Carbic can serve you.

Complete information on request.

Carbic Mfg. Co.
DULUTH, MINN.

NEW YORK CHICAGO LOS ANGELES
BOSTON ATLANTA, GA.
CHARLOTTE, N. C., KANSAS CITY, MO.

EL PASO, TEX. 412 Myrtle Ave.
DENVER, COLO. Hendrie & Bolthoff M. & S. Co.

NEW ORLEANS, LA.
Woodward, Wight & Co.

DALLAS, TEXAS
Briggs-Weaver Machinery Co.

PITTSBURGH, PA.
Frick & Lindsay Co.,

Warehouses and Representatives in other principal cities

W. D. BAUGH

GREENWOOD WELDING WORKS

OXY-ACETYLENE AND ELECTRIC ARC WELDING

TELEPHONE 165

GREENWOOD, MISS.

July 27, 1924.

Electric Arc Cutting & Welding Co.
Newark, N.J.

Gentlemen:-

Last week, July 21 to 26 inclusive, I welded with your "Alternarc" machine as follows:

For	Work	Price
Day & Night Garage	Magneto coupling	$ .75
Auto Supply Co.	Horn Bracket	.75
Auto Sales Co.	Disc Wheel Rim	2.00
C. E. Wright Ice Co.	Fire tools & small gear	4.00
Auto Sales Co.	Weld rim lug	.75
J. F. Bobbitt & Co.	Weld handles on roofing tools	1.00
Roland W. Jones	Cast iron water filter	20.00
Manning Gin Co.	Cast iron water jacket for 100 HP crude oil engine	45.00
Day & Night Garage	Spring bumper	2.00
Tourist	Frame brackets	3.00
M. J. White	Brake bracket (Malleable)	4.50
Auto Sales Co.	Maxwell flywheel housing while on car	12.00
Auto Sales Co.	Studebaker drive shaft	3.00
Tourist	Broken frame	10.00
J. F. Melton	Rim lug	.75
Memphis Hardwood Lumber Company	Lumber truck frame	7.50
Van Noy-Interstate News Co.	Large cast iron boiler section	60.00
Quiver River Gin Co.	Cast iron water jacket for 100 HP Coal oil engine	45.00
Dr. S.L.Burchfield	Three cast iron boiler sections for Ideal heating system	60.00
G. C. Herring	Tire shrinker	8.00

This does not include gas welding and cutting done during the same six days. My apprentice does most of the gas welding, and is fast learning the arc. I have held him back to a certain extent in learning the arc, for fear he will tire of using the torch, and I do not care to handle the torch more than is absolutely necessary. In conclusion will say that your machine has never failed us.

Yours truly,

W. D. Baugh